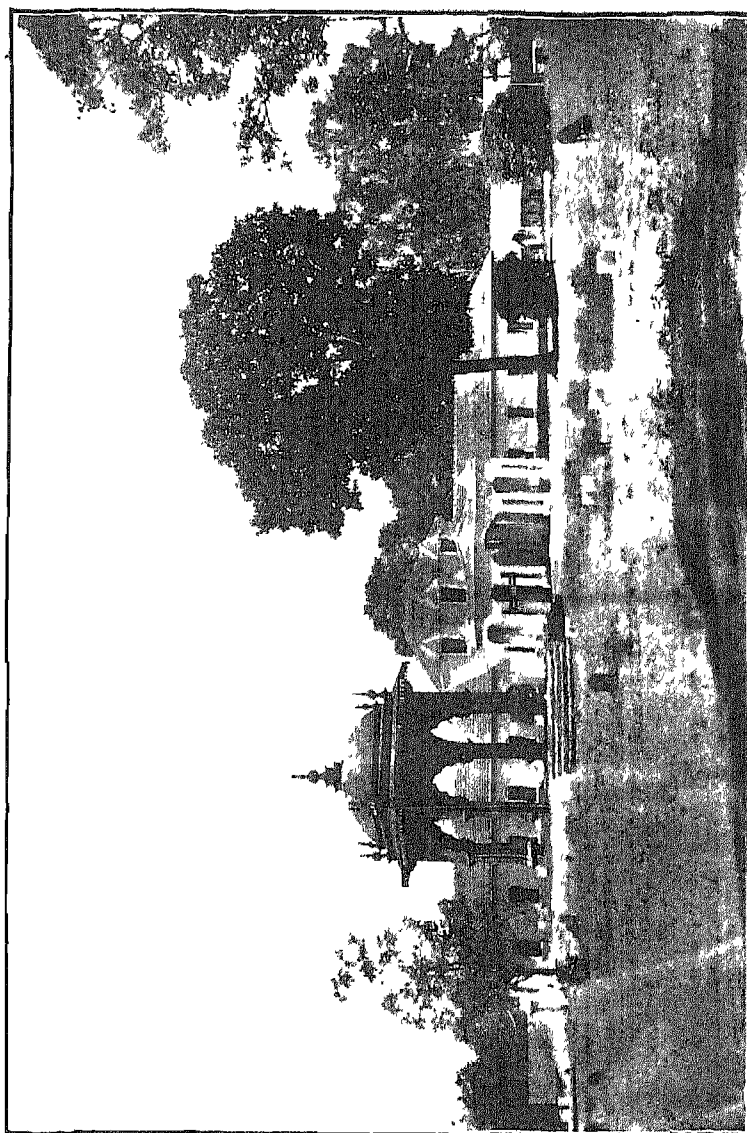




A HANDBOOK OF SERICULTURE

I. REARING OF SILK-WORMS

BY

M. YONEMURA,

Late Silk Expert, Sericultural Department

AND

N. RAMA RAO, B.A., B.L.,

Superintendent of Sericulture in Mysore

WITH ILLUSTRATIONS

9848

MYSORE

PRINTED AT THE GOVERNMENT BRANCH PRESS

9848/36



IARI

PREFACE

THIS book is concerned mainly with the rearing of silk-worms, and is intended to be the first of a series of manuals dealing with all branches of the Sericultural Industry. Seed Production, Diseases of Silk-worms, Reeling and Economic Organisation will be treated in subsequent volumes.

The substance of this work has been in great part contributed by Mr. M. Yonemura, the Japanese Expert, with whom I had the privilege of being associated for four years; but the arrangement and exposition are almost entirely mine, and mine also is the responsibility for all errors and shortcomings. The results here given have, in most cases, been either worked out or verified in the institutions of the Sericultural Department of Mysore of which I am in charge. Though the main purpose of the book has been to give to our rearers in an easily understandable form the best and most recent information on the technique of their business, it will not, I trust, be without interest to the general reader who realises the importance of Sericulture to the country. It was perhaps unavoidable that I should write with special reference to conditions in Mysore, with which alone I am intimately conversant; but there is no doubt that the methods and general principles explained in the book will be found applicable to all parts of India—at least to all

those parts of India where the polivoltine races of silk-worms are reared and Sericulture is an agricultural subsidiary industry.

My grateful acknowledgments are due to Dr. Leslie C. Coleman, Director of Agriculture, who looked over the work in manuscript and made valuable suggestions, and to Mr. B. Srinivasa Iyengar of the Government Branch Press, who spared no pains to send this little book forth in an attractive form.

Exhibition Buildings, }
Mysore.

N. RAMA RAO.

CONTENTS

	PAGE
CHAPTER I.	
Object of rearing, and essential requirements	... 1
CHAPTER II.	
Rearing house and equipment	... 6
CHAPTER III.	
Incubation and brushing	... 19
CHAPTER IV.	
Harvesting and storage of mulberry leaves	... 30
CHAPTER V.	
Preparation of leaves for feeding	... 38
CHAPTER VI.	
Feeding	... 41
CHAPTER VII.	
Cleaning	... 50
CHAPTER VIII.	
Spacing	... 56
CHAPTER IX.	
Special treatment required during different periods	... 64
CHAPTER X.	
Particular treatment during each age	... 74

	PAGE
CHAPTER XI.	
Mounting and harvesting 	79
CHAPTER XII.	
Things which a rearer ought to know: silk-worm diseases, seed-selection, rearing-room hygiene 	90
APPENDIX I	
Instructions and rules for Government grainages ...	109
APPENDIX II	
Instructions for the disinfection of rearing houses and appliances 	117

LIST OF ILLUSTRATIONS

	FACE	PAGE
Central Sericultural Institute, and Office of the Superintendent of Sericulture in Mysore ...	<i>Frontispiece</i>	
From cocoon to finished silk ...	...	2
Rearing room appliances ...	...	9
Straw-rope cocoonage ...	...	15
Bush cocoonage ...	...	16
Mounting worms in <i>chandrikes</i> ...	...	17
Life chart of silk-worm : egg to moth ...	...	18
"Ants," or newly hatched worms ...	...	23
Chopping leaves and feeding ...	...	40
Use of paper-net and of paddy husk for changing beds ...	...	54
Straw-rope net for cleaning ...	...	55
Worms of various ages ...	...	59
Silk-worms in the 5th age (after passing 4th moult) ...	...	60
Interior of Mysore Filature: apparatus for testing the size of silk ...	...	108

A HANDBOOK OF SERICULTURE

CHAPTER I.

Object of Rearing, and Essential Requirements.

OBJECT OF REARING.

REARING silk-worms can be regarded from two points of view—the technical and the commercial. Though these two points of view at first sight seem to be very different, they are really not so. The technical man naturally attaches most importance to the healthy development of the silk-worm, in all its stages, without special regard to expense, or to money return. The commercial man, on the other hand, pays special attention to the profit or money return, and regards the health and development of the worm as merely a means to this object. As, however, profit can only be secured if the worms are healthy and well developed, in practice both these considerations harmonise and make the proper rearing of silk-worms the central problem of sericulture. The rearer's problem is simply this:—

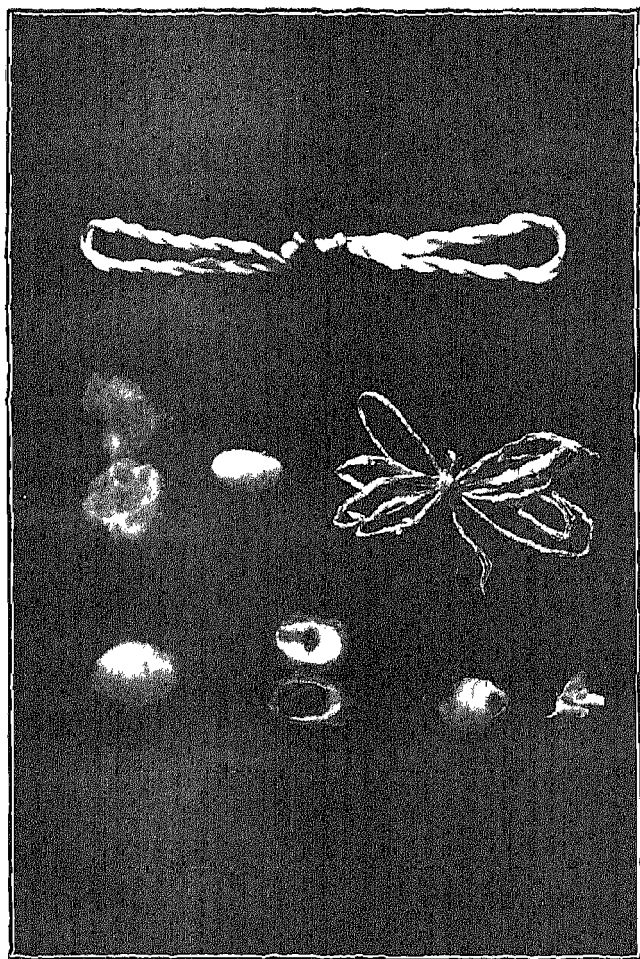
To what extent can expenses in rearing be cut down without injuring the health and strength of the worms in a manner which would diminish the quantity and value of their cocoons? It may sometimes happen that it is possible to cut down expense to a large extent, without diminishing the value of the output to the same extent, so that the *net* result of the diminution of cost is a profit. What we mean is this: Suppose a man by spending Rs. 30 in rearing silk-worms gets 52 lbs. of cocoons worth about

Rs. 39; it is quite conceivable that when conditions are favourable he might by spending only Rs. 24 get 48 lbs. of cocoons worth about Rs. 36. Thus, though the total quantity of cocoons produced by him would be 4 lbs. less than in the first case, his profit would be Rs. 3 more. But this is only possible when all the conditions—such as temperature, humidity, supply of leaves, etc.,—are favourable. The least unfavourable variation in the conditions would deplete his trays of underfed or neglected worms, and destroy his rearing; while a brood of healthy well fed worms would have tided over the trouble. This method of seeking larger net results at the expense of the worms is full of danger, and will, in the long run, be disastrous to the rearer. If the raiyats adopted this penny-wise pound-foolish policy, the sericultural industry would be in a very dangerous way, and subject to the risk of total destruction in a bad year. The race of worms would also steadily deteriorate, and there would never be any possibility of improvement. It will thus be seen that good technical rearing—which we may call rational rearing—is really good commercial rearing also.

ESSENTIAL REQUIREMENTS.

Food, air, temperature, and humidity.

Having now arrived at a clear idea of the object of rearing, we shall next proceed to a consideration of the right method to adopt for attaining that object. To secure to our silk-worms robust health and perfect development, we have to understand their essential requirements, and attend to those requirements at the proper time. The most essential requirements of the silk-worm—as indeed of all living creatures—are *food, air, and suitable temperature and humidity*. There are quite a number of other requirements which, if attended to in time, would conduce to the health and development of the worm; but the four that have



FROM COCOON TO FINISHED SILK

Cocoon : cocoon cut open, showing pupa and cast larval skin; "pierced" cocoon, and moth; cocoon stripped of "floss"; the floss which has been separated; waste (floss separated out in reeling); silk (substance of the continuous filament in cocoon)

been mentioned above are of such prime importance that they may well be considered essential. We shall consider them one by one.

Food.—Mulberry is the only satisfactory food of the silk-worm. Of mulberry there are many kinds, but *Morus alba* is the kind most frequently used. The mulberry cultivated in Mysore is probably *Morus alba*, and is very suitable for silk-worm food. There are, of course, also other leaves that can be fed to silk-worms, such as the Osage orange, the lettuce, and the ordinary *peepul*; but these can only be regarded as a mere make shift, and can never become a satisfactory substitute for mulberry. They can, of course, be used to keep the worms alive when, owing to some accident, mulberry cannot be got. Fed on these leaves, the silk-worms would soon suffer in growth and vigour, and fall an easy prey to diseases. Even the survivors would be miserable specimens, spinning flimsy cocoons if they do spin cocoons at all. Mulberry being practically the sole food of the silk-worms, it is at once obvious that the quality of the mulberry has a predominating influence on the development of the worm, and the value of the cocoon.

Air.—It need not be mentioned here that air which is essential to all living-beings is also essential to the silk-worm. The health of the silk-worms and the yield of silk depend greatly upon the purity and sufficiency of the air supplied to them. Therefore, we should select for rearing a proper room with a sufficient supply of air and a good ventilation. The worms must also have sufficient space given them in the course of rearing. We should not overcrowd them in a small room, especially in a small room which has no sufficient supply of air.

Temperature.—Temperature is a factor of the utmost importance in rational rearing. It is a clear fact that a suitably high temperature makes development rapid and healthy, while a lowering of temperature retards growth. The proper degree of

warmth makes all the organs function vigorously, and the worms consume more food, and build more body-tissue. A low temperature, on the contrary, makes the bodily functions dull, with the result that less food is consumed, and growth is slow. At a very low temperature, the functions get so dull that the worm is barely alive and can be kept for prolonged periods without food. Too high a temperature on the other hand, makes the functions abnormally quick so that the worm has too little time at each stage for full and healthy growth. It passes hurriedly from stage to stage, and in the end becomes a weak worm with small silk glands, capable of spinning only a flimsy cocoon. Too high a temperature also makes the worms quite un-uniform, for the weaker worms suffer more than the stronger and these differences become accentuated. This makes the rearing very difficult, especially during the moult periods. The most suitable temperature for rearing silk-worms is between 70° and 80° F. The best temperature in each case depends on the variety of the worm reared. For polivoltine worms—such as the Mysore worm—any temperature between 75° and 80° F would do admirably. For univoltine worms, a temperature between 70° and 75° F would be the best; while bivoltines would thrive well in temperatures between 75° and 77° F. In practice, it would be a good plan to start a rearing with a comparatively high temperature within the above limits, and gradually lower it as the crop progresses towards maturity. This would secure reasonably rapid growth in the earlier stages, while allowing time for perfect development during the age when the silk glands are secreting their precious fluid.

Humidity.—Quite as important as temperature and closely connected with it in its influence in the rearing room is the humidity of the air in it. Silk-worms can bear a comparatively high temperature when the air is dry. A combination of humidity and

high temperature is about the worst thing that can happen to a rearing. Considered by itself, humidity influences the *health* of the worms as temperature influences their *development*. Too little humidity makes the mulberry leaves fed to the worms rapidly wither and shrivel up, so that they become unfit for silk-worm food. In these circumstances the silk-worms fail to get sufficient nourishment, however large may be the quantity of leaves supplied to them, and suffer from debility and its consequent evils. Too high humidity, on the other hand, is an even greater enemy. It favours the growth of the germs of all the silk-worm diseases, and in combination with high temperature, makes successful rearing almost impossible. This subject will be dealt with in greater detail later on, and expedients will be suggested whereby the evils resulting from too much and too little humidity can, to some extent, be controlled.

CHAPTER II.

Rearing House and Equipment.

SILK-WORMS—at least domesticated silk-worms—require a house or room for being reared in ; so a knowledge of the requisites of a good site is quite necessary. Of course, in the large majority of cases, when a man begins to rear silk-worms he does not build a new house or room, but proceeds to rear in what he considers the most suitable part of his existing house. A correct knowledge of the points necessary to make a good rearing room would be of great value to him in selecting a suitable part in his own house. It is impossible to lay down hard and fast rules as a correct decision can only be reached on a close study of local conditions. It can, however, be generally laid down that the site must not be water-logged and that it must command a plentiful supply of fresh pure air, without being exposed to violent draughts or direct heat of the sun. If the site is damp, it should be surrounded by a drain sufficiently deep to draw off the moisture, or it must be given a basement high enough to secure a dry floor. If the air is moist, the effects can in great measure be mitigated by securing a free current of air by opening suitable windows. If the moistness of the air is due to the proximity of a river or a lake, or a swamp, a direct current of air from these sources should be avoided by closing up ingress from that side by raising bushes or trees or walls or other wind screens, and such moist air as enters should be given free egress from the room. If the air is stagnant owing to too thick vegetation all round, a space should be cleared to admit of free circulation. In

the opposite case of too exposed a situation, laying the rearing room open to violent draughts of wind, and to direct heat from the sun by day and direct cold from chill winds at night, this should also be counteracted, as far as possible, by raising trees and suitable shelter. The orientation of the room should be such that its interior is protected from the direct afternoon sunlight. Sudden extremes of temperature are injurious to the worms, and radiation of heat by night when the air is cold, from walls which have absorbed heat during the hot hours of the day is particularly harmful.

The next question is—Which direction should the rearing room face? The best orientation would be north and south, the room facing north, with the door open to cool breezes, with a window on the south side to aid ventilation, and with the sides of the room east and west. If this ideal direction cannot be secured, the next best would be a north-west face, and south-east back, with provision for free air as above. If there is no choice in the matter and a room has to be built or selected facing east or west, east face is better than west face. A room which faces east would be quite all right in the morning, as the rays of the early sun would warm the cold night air in a desirable manner; but the afternoon sun would make the room get hotter and hotter, leading to drying up of leaves with its attendant evils. A room facing west would be the least convenient for rearing purposes. In all cases it must be remembered that sheltered verandahs and shade trees exercise a very beneficial influence in moderating heat. Especially when a room faces east or west, broad verandahs should be provided or trees planted to cast a shadow on the exposed side. In distributing space inside a room or house, mulberry leaves and silk-worms should not be kept on the western side. There is usually much difference in afternoon temperature between the eastern and western parts of the same

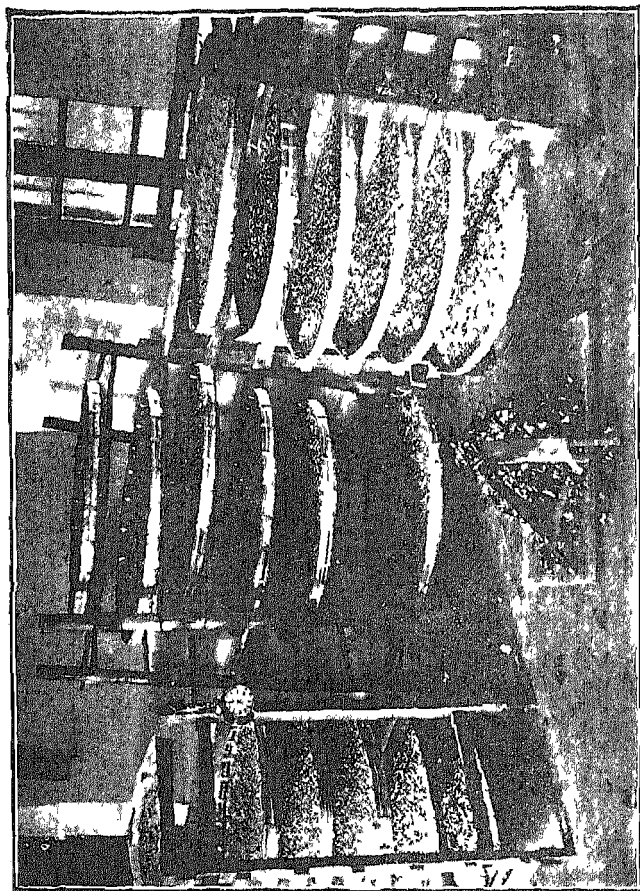
room, the western being much hotter. In distributing space in a house, the same principles as laid down above to regulate the orientation should, as far as possible, be observed. Opposite to the door, a window should always be provided to induce free ventilation.

CONSTRUCTION OF REARING HOUSE.

In building a rearing house, there are a few important things to bear in mind. The depth or width of the room must be small in proportion to its length or frontage, and must not in any case exceed 15 or 18 feet. A broad room presents inequalities of temperature, as the air does not circulate across it as freely and quickly as in one which is not so broad, and there is consequently something like stagnation. If it becomes necessary to extend the rearing room, additional space should be secured by increasing its length, and not its breadth.

Windows should be provided so as to admit of free passage of air. It would be specially good if ventilators are furnished also on the upper parts of the walls, opposite one another. Attention has already been drawn to the beneficial effect of verandahs, and these should be from 4 to 6 feet broad at least. If verandahs cannot be afforded on both sides of the room, one side at least, and that the side most exposed, should be so protected.

The roof should be of non-conducting material, and amply provided with ventilators. The best ventilation would perhaps be a raised ridge along the gable; but where this is not possible, a number of openings protected against inclement weather may be provided. When it is said that a non-conducting roof is preferable, it will be readily understood that thatch or wood is better than tiles, and that metal, such as corrugated zinc sheets, is worst of all. When the roof has a wooden or other ceiling, the latter



REARING ROOM APPLIANCES

Stand, trays, wet and dry bulb thermometers, chopping board, chopping knives broad and narrow, and time piece

should be provided with shuttered openings in the corners, and in the centre. It may be said generally that a high roof is always better than a low one, as it takes away much of the evil effects of variations of outside temperature.

These might at first sight appear mere counsels of perfection which could be adopted only by well-to-do persons who intend constructing new rearing rooms, and not by poor raiyats who have to conduct their work in a part of their small dwelling houses. But the main point is that every rearer should know clearly what is good for the worms and what is not; and this knowledge will enable him to make the best of his limited resources. He will be able to select the best room for his purpose in his small house, and to alter and improve it at small cost, by opening a window here, a door there, a sky light in the roof, by putting up a thatch pent against a western door or window, by planting a few trees, and so on. The most important principles can be easily remembered by all, and are these—*avoid damp, avoid stagnation of air, also avoid direct and too strong draughts of air, and avoid exposure to hot sunlight and radiation; secure an equable temperature, and good ventilation, and see that there are facilities for protection against too great heat and too great cold.*

EQUIPMENT.

After a proper rearing room has been built or selected, the next thing to consider is—What are the articles with which it should be furnished before rearing is commenced? We must distribute the space in the room among the worms and for this we require stands and trays. We have to attend to their cleanliness and change them from beds soiled with their excreta and leavings to fresh clean ones; hence we must have mats, nets, winnows, sieves, etc.; we must prepare their food for them, and therefore

we must have chopping knives, boards, etc. We must know the temperature of the room, and so we must have a thermometer. It would be better to have a hygrometer also to know the humidity, but these instruments are probably beyond the means of the average Mysore rearer. The use of each of these appliances will be detailed fully when we treat of the operations in the rearing room. Here we shall simply describe them.

The *stands* are frames on which are held the trays on which worms are kept during rearing. In Japan, where the raiyats are comparatively poor and have also learnt from long experience, this framework consists of flat wooden uprights fixed in the floor at intervals of 8 to 10 feet. These uprights are pierced with holes through which bamboos are passed to form a number of scaffold-platforms for keeping trays, which are bamboo oblongs usually of $2\frac{1}{2}$ by $3\frac{1}{2}$ feet in size. In China, as in India, the stands are of bamboo; their size varies with each locality, and depends on the size of the tray. In Europe, they are of more solid construction, and are of woodwork. In some countries, (formerly in some parts of Korea, and in Kashmir) stands and trays are not used at all, but the worms are reared on the floor. It must be clearly understood that there is no special merit or virtue in any particular style of stand, and that the only aim should be to choose a material which is light, cheap and durable, and build it into a stand which, while allowing as large a quantity of worms to be reared as possible in the room at our command, also permits of each worm having as much air and space as it requires for its health and development. The shape of the stands must thus adjust itself to the needs of each locality, and to the requirements of changes in methods of rearing. In Japan, the method of feeding branches to the worms is coming into vogue, and the result has been that the stands above described are being suitably

modified. The stand then, must be such as will allow as large a number of worms to be kept in the room as possible, and allow of sufficient space between tray and tray for the free passage of air. Under ordinary Mysore conditions, we may say that the stand must be 5 to 6 feet in height and that the bamboos for trays should allow for a space of 10 inches to 1 foot between tray and tray. If the rearing room is specially high, a higher stand might be constructed, but ordinarily, a higher stand would be too near the roof, and also inconvenient for handling the topmost series of trays.

TRAYS.

Trays are portable receptacles for keeping worms during rearing. There are many kinds of trays, differing from one another in material, shape, and size. In Europe, trays are made of wood, but in most oriental countries bamboo is almost invariably employed. The shape may be rectangular or circular. In Europe and in Japan rectangular trays are most ordinarily used. In China and in India, circular trays are the rule. As to size, there are great differences in the types used in different countries. The European tray is usually very long in relation to its breadth, the length being at least twice the breadth, which is usually 2 or $2\frac{1}{2}$ feet. In Japan, the most common size is $2\frac{1}{2}$ by $3\frac{1}{2}$ feet. In China, the most popular size of tray is 2 to 4 feet in diameter. In India, all sizes varying from 3 to 6 feet in diameter are found, but the one mostly employed is about 4 feet. The Japanese tray is usually of mesh bamboo work; and a mat or paper has to be fitted inside for the worms. This is a very convenient contrivance for changing beds. The mat usually employed is of paddy straw held together with lines of string, very much like the reed *mandaliges* used in Mysore. The straw is arranged with interstices to admit of ventila-

tion, and the whole thing can be rolled into a very compact mass for being put by when not in use. The cost is not much, and the mat can be washed and used repeatedly. The use of this mat is quite analogous to the use of a bed sheet on a bed, and by facilitating frequent change ensures cleanliness and sanitation. It is invaluable as a preventive of spread of silk-worm diseases. In Europe, paper is generally used, but it has the disadvantage of not admitting ventilation and cannot be cleaned. The same paper cannot be used oftener than once or twice as it gets too soiled, and it is therefore more expensive in the long run. Whatever the material, shape, or size of the tray, it is invariably furnished with a raised edge all round.

In the selection of the material and type of tray, the main considerations are just these:—*The material must not be too costly, for sericulture is an industry in which luxurious appliances are out of place: nor ought it to be too flimsy and perishable, for this would make it costly in the long run.* Bamboo, though it has its disadvantages such as liability to attack from borers and white ants, satisfies almost all reasonable requirements, and its almost universal use in old sericultural countries is in itself a proof of its suitability. In regard to the size, the sole criterion is convenience in use. A very heavy material in tray would necessitate equally heavy and strong material in stand, and labour in handling in rearing.

NETS.

Nets are used for changing beds. In Mysore, when silk-worms are to be changed from one bed to another, they are gathered together roughly by the hand, and removed by handfuls to another tray. This primitive method injures the worms, and especially in the earlier stages, a good many worms are lost. It is very necessary that this waste should be avoided by

employing nets. The use of a net in cleaning is simple and easy. The net is spread over the worms, care being taken to choose a net with a mesh of size suited to the worm. A feed of mulberry is sprinkled over the net. The worms rise from the old bed through the meshes, and get on the feed. The result is that they are completely separated from their old bed by the net. After one more feeding the net with all the worms upon it is transferred to a new bed.

Nets are of many kinds, according to the material used for them, and are made with various sizes of mesh according to the age of the worms for which they are employed. They are made of cotton thread or linen, or of any kind of fibre or grass, and for the larger meshes, intended for the later ages, of rope. The mesh should be a square of which one side is of the same length as the silk-worm of the age when it is to be used. In the later ages, it is preferable to use fairly thick rope, as in these ages a large quantity of leaf has to be used for feeding each time and litter accumulates so fast that it is necessary to provide for ventilation, and a net of thick rope does this. Coconut or palmyra fibre is very suitable material for nets at this age. Paddy husk is sometimes employed with advantage either along with nets, or independently as a substitute, for changing beds. The method of using paddy husk will be described later on under 'cleaning.'

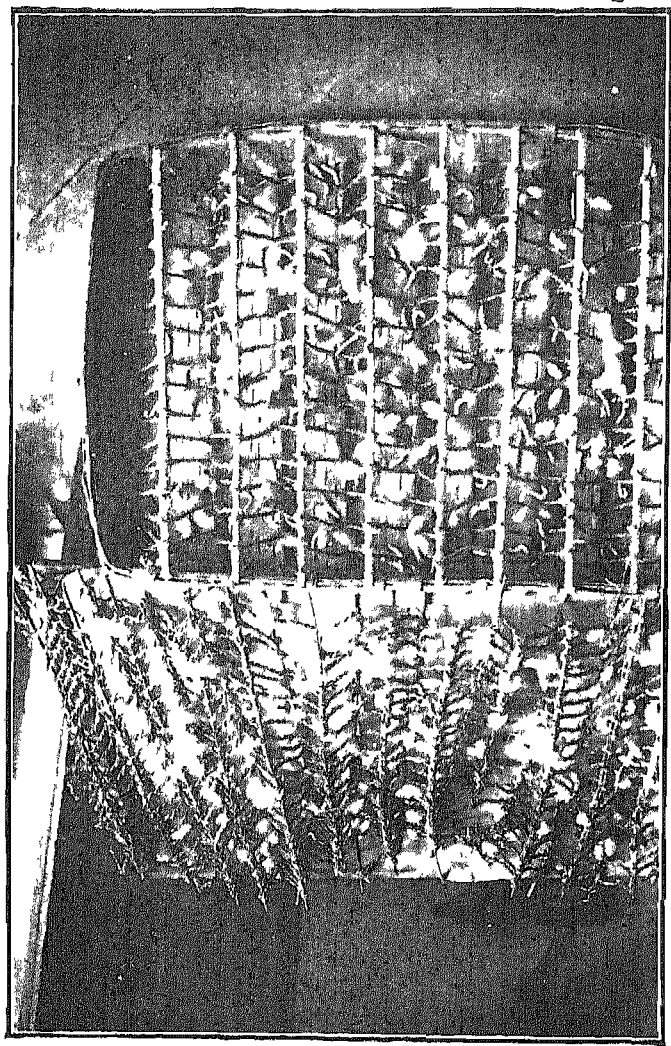
FEATHER.

A *feather* or a whole wing of feathers, or a feather brush, is a most useful auxiliary in the rearing room. They are almost indispensable for brushing newly hatched worms. They are useful in changing beds in the earlier ages, and save worms from the injurious contact of hands. A single feather if large enough, can be used for the purpose; or a number of smaller feathers can be tied together into a brush, or a whole wing might be taken and fitted with a handle.

APPARATUS FOR PREPARING LEAVES
FOR FEEDING.

As the mulberry leaves are generally chopped for being fed to the worms, a *chopping board*, and a good *knife*, are a necessary part of the equipment of a rearing room. To these may be added a *sieve* and a *winnow*. As the sizes into which the leaves have to be cut vary with the size of the worms, different sizes of knives would be convenient. In Japan, they use 4 or 5 sizes. In the later ages of the silk-worm when a large quantity of leaves has to be cut, the knife may be about 2 feet long and 8 inches broad. A broad knife helps in uniform cutting, while a narrow one does not cut in a true line. The knife should be sharp when used, as a blunt knife bruises and crushes the leaves instead of cutting them clean. In Mysore, two knives, a smaller one for cutting leaves for *chawki* worms, and a bigger one for the later stages, would answer all practical purposes. It would be advisable to have a mat or cloth for spreading before the chopping board for receiving the cut leaves, as it would not be good to let them fall on the floor. The use of the sieve in the earlier stages is for ensuring uniformity in size in the cut leaves; and of the winnow in the later stages to separate stalks, and heavier substances from the feed. A *basin* for the tender cut leaves for young worms, and a *basket* for the matured leaves for developed worms may also be provided.

It is only necessary to add that a suitable arrangement must be made for keeping mulberry leaves intended for silk-worm food. Keeping the leaves in a big heap on the floor in a corner of the rearing room is about the worst thing that a rearer could do. It is obvious that the leaves rapidly wither owing to evaporation, especially in the dry season; and besides, fermentation takes place inside the leaf heap, altering the quality of the contents very much



STRAW ROPE COCOONAGE

for the worse. More than all things else, the leaves are in danger of getting infected with disease germs from the dust of the room, especially during such processes as cleaning, changing beds, etc. Some raiyats are in the habit of storing leaves in tall bamboo baskets and covering them up with cloth. This is certainly better than promiscuous heaping on the floor; but even so, the leaves are too tightly packed, and fermentation sets inside the unventilated bulk. The best method would be to employ square bamboo baskets about 4 feet $\times$ 3 feet $\times$ 10 inches in size, put the leaves in them without pressing them in, and cover the whole with a wet mat, or cloth, or gunny bag. These baskets can be kept in a part of the rearing room on a suitable bamboo rack.

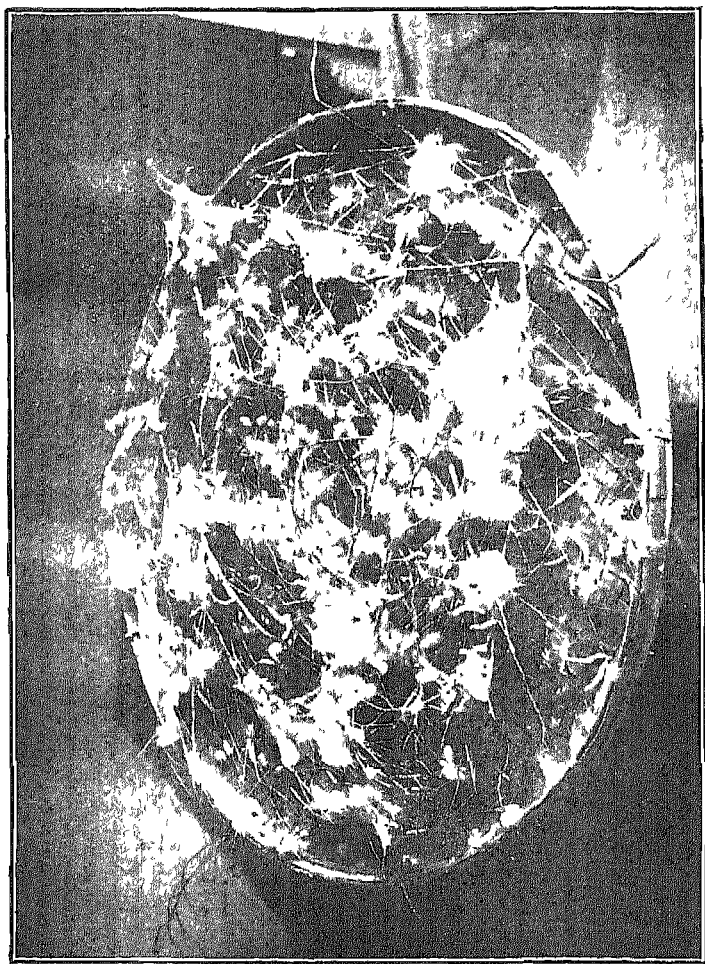
COCOONAGE.

By *cocoonage* is meant the contrivance used to enable ripe worms to spin cocoons. The most familiar form of cocoonage in India is the *chandrike*, which, as every one knows, is a rectangular bamboo mat on which is fixed a labyrinth or spiral of bamboo tape. In Japan three kinds of cocoonages are in common use, *viz.*, the folded straw cocoonage, the centipede rope cocoonage and the straw rope cocoonage.* (The folded straw cocoonage consists of bundles of straw which are bent at short intervals so as to present a zig-zag outline; and these are fixed in the desired position by means of a rope. The centipede rope is a rope in which bundles of straw are fixed at short intervals, so that the rope, with the ends of the twigs sticking out presents the appearance of a centipede. This rope when not in use can be hung up on the wall and is very convenient to use. The straw rope cocoonage is harder to describe than to make. Across the breadth of a tray, at intervals of about $3\frac{1}{2}$ inches, thin strips of bamboo are fixed. These strips are a height of about $3\frac{1}{2}$ inches from the bottom of the tray.

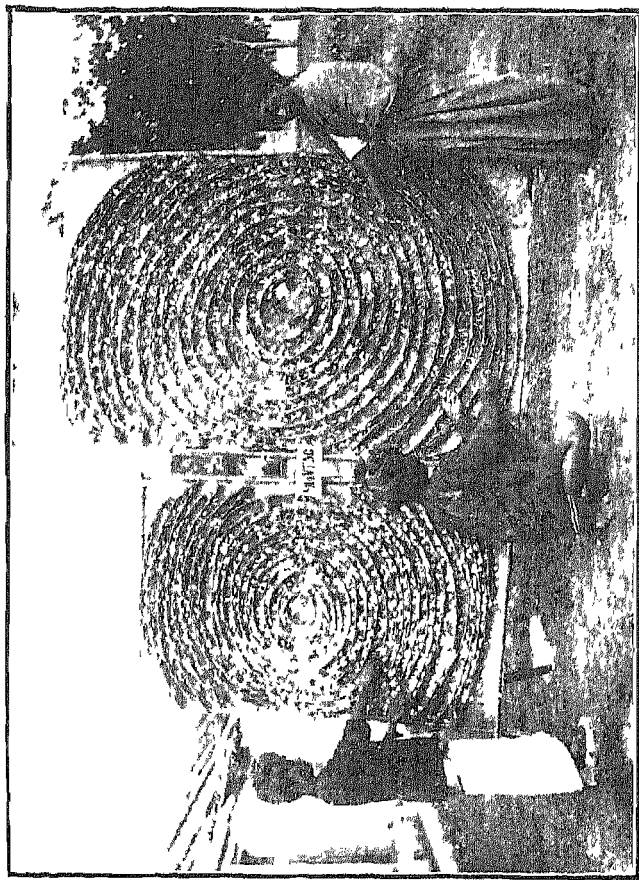
On the bottom of the tray, in the middle of the intervals, and in the same direction as the top bamboos, another series of parallel bamboo strips is fixed; then the straw ropes are fastened at intervals of about an inch across these bamboo strips, passing zig-zag over the top bamboos, and under the bottom ones, so that the whole presents the appearance of a net folded zig-zag-wise.

In China, they employ a bamboo frame 4 to 5 feet long and $2\frac{1}{2}$ to 3 feet in breadth along the length of which 6 to 8 split bamboos are fixed. To these are fastened innumerable thin bamboo strips from $\frac{1}{3}$ to $\frac{1}{2}$ an inch in breadth, bent in figures of 8, and these afford points of support to the worms to spin cocoons. These are placed supported against each other and worms are mounted in them for spinning. In Europe soft and pliant branches of plants are used, those most ordinarily employed being those of the rape plant. In selecting these bushes, care is taken that there are plenty of fine plant twigs in it. In Indo-China and in India, the *chandrike* is the most popular contrivance. This needs no description, as every one is familiar with it. It may be observed in passing that the interval between the windings of the tape is sometimes too great, and that the worm is consequently subjected to much disadvantage in spinning a cocoon.

Whatever the material employed, and whatever the size or shape of the contrivance, the following points must be borne in mind. The worm before it spins has to stretch a filament across the supports, and therefore the material had best be flexible so as to enable the worm to adjust itself according to its convenience. If the material is hard and inflexible, it throws on the rearer the responsibility of studying the convenience of the worm, and arranging the shape of the cocoonage to enable it to spin to best advantage. Supposing the cocoonage is of stiff material, like the *chandrike*, and the space between



BUSH COCOONAGE



MOUNTING WORMS IN CHANDRIKES

Left— improved *chandriks* note the closeness of the spiral

Right— ordinary rayats' *chandriks*, note the width of interstices

support and support is too broad, the worm has to waste a good deal of valuable silk to stretch across the points. Another point to bear in mind is that the worm has to complete its excretions before starting to spin a cocoon, and that it is therefore necessary to provide for free passage of air so that these excreta might dry, and not remain wet and stain the cocoon. The cocoonage should also not be of material which absorbs the liquid excretion of the worm, for the place of absorption will remain moist, and will discolour the cocoon spoiling its lustre and making it difficult to reel. Such material also absorbs moisture from the air, with the same effect on the cocoons. The cocoonage, whether bushes or straw or bamboo, should therefore be very dry, and should admit of free ventilation.

OTHER APPLIANCES

We next come to a class of appliances which presuppose a certain standard of knowledge and financial ability on the part of the rearer which are unfortunately not commonly found in Mysore. We mean, a *hygrometer* to ascertain temperature and humidity, and a *sprayer* and *disinfectants* such as formaldehyde or corrosive sublimate. Temperature and humidity are of such supreme importance in rearing that the poorest and least educated raiyat has in practice to form an idea of them with his unaided natural faculties; and disinfection is of such vital necessity that even without special apparatus or drugs he will have to do the best he can with such natural disinfectants as fresh air, clean water, and strong sunlight. Yet it is necessary to know the best and most efficient methods, even if they are not to be immediately carried into practice; and the time is perhaps not far off when the more important sericultural villages will invest in these appliances for the common benefit of all their rearers.

The raiyats ought to know about these appliances in order that they might get assistance from the Government Department or other agencies, when they cannot provide the appliances themselves. A *thermometer* at least is not very costly or difficult to use, and therefore many raiyats may provide themselves with it. A Fahrenheit mercury thermometer is the most convenient to use. An ordinary compressed air sprayer would be very useful with formaldehyde. A sprayer for use with corrosive sublimate must be of glass as metal is corroded by the solution, but corrosive sublimate is a highly poisonous substance, and would be dangerous if not used with care and knowledge. In Mysore the use of a stove is seldom required to warm up a rearing room, but in cold countries a stove is a very necessary appurtenance. Even in Mysore, in the cold and damp months, a stove could be very advantageously used at the time of spinning. When it is damp and chill, it would be useful to warm and dry the air in which *chawki* worms are reared—and a stove would enable this to be done. A pot stove, pierced with holes below for draught, would do excellently. It must be said, however, that a fire which flares up and burns out quickly, causes too sudden a rise of temperature in the beginning and too sudden a fall afterwards; moreover the consumption of fuel is also great. A slow fire, which remains alive under ashes diffuses a more even warmth, and also costs less. This would be more useful in a rearing room.

CHAPTER III.

Incubation and Brushing.

INCUBATION.

BY incubation is meant the preparation of eggs for hatching. In the case of univoltine eggs the period of incubation begins when the eggs are taken out of cold storage. With polyvoltine eggs—like those of the Mysore race—the period of incubation commences immediately after the eggs are laid.

During incubation, maintenance of the proper temperature is extremely important. Too high a temperature, though it makes the eggs hatch earlier, results in a large proportion of the eggs dying or becoming so weak that they do not hatch at all. The hatched worms are also lighter than they should be, and remain below the normal size throughout the rearing. The cocoons spun by them are small, and poor in silk content. The effect is thus loss of eggs, poor worms, and small harvest. Too low a temperature, on the other hand, prolongs the period of incubation. A number of eggs do not hatch at all, and the hatchings themselves do not take place at one time, but in batches, irregularly. This adds to the difficulty of rearing. The worms, indeed, look big and strong, but they are really not hardy and resistant to disease, and they easily fall a prey to diseases. The survivors spin big cocoons, but as a good many eggs remain unhatched and a good many worms die during the rearing, the harvest will not be a profitable one on the whole. The cocoon, though big, will be thin in silk layer, containing a comparatively poor quantity of silk, and its quality will also not be good.

The question now arises—What is the proper

temperature? The proper temperature has to be determined in relation to the race of worm reared, whether univoltine or polivoltine.

The *univoltine* eggs require, as a rule, a slightly lower temperature than polivoltine eggs. For univoltine eggs, the ideal temperature for incubation is 72° or 73° F. An average temperature of between 70° and 75° F would be quite suitable. In practice, it would be almost impossible to altogether eliminate variations arising from the nature of things, such as sunrise, noon-day, sunset, rain, storms, etc., but it is important to confine these variations within as narrow a range as possible, and to see that the average temperature is within the limits specified above. We have said that an *average* which lies between 70° and 75° F would do well; the *fluctuations* should be kept between 65° and 80° F. Anything less than 65° in fluctuation is too low a temperature; anything more than 80° would be too high. The smaller the variation, the more perfect is the incubation. If the average temperature falls below 70° or rises above 75°, the temperature may be said to be too low or too high—and especially if the range of variations is also great, the evil effects are more pronounced.

The proper temperature for *bivoltines* is an average between 70° and 76° F, with a range of variation limited to 65° and 80° F. If this condition is observed, the results will be very good. If the average is about 80° F, the results will not be so good in any particular, and the time taken for maturity will also be longer. If the average is about 65° F, on the contrary, the hatchings become ununiform, there will be dead eggs, and the worms will not develop properly, the rearings consequently resulting in a smaller quantity of cocoons of poorer quality. If there is also great fluctuation in temperature, the above evil results will be emphasised. In regard to bivoltines, there is a very important point to bear in mind. The eggs of

the first generation which are intended to be reared immediately as the second crop, have to be treated differently, if their true nature as bivoltines has to be preserved. If they are subjected to a temperature of above 65° F, they turn black and behave like univoltines. To maintain their bivoltine nature, they have to be kept at an average temperature of about 60° F, the fluctuations never going above 65° F. A fluctuation on the other side of low temperature might reach 55° without any damage. It would be safer—if the object is to preserve the bivoltine nature only—to keep the temperature below 60° than above. It is essential that this should be carefully done from the 5th or 6th day after oviposition. As, however, a slightly higher temperature tends to produce stronger worms and better cocoons in the result, a temperature of about 70° may be used during the first 4 or 5 days after oviposition. Or, even, a slightly higher temperature than 70° might be used, and gradually brought down during the next 4 or 5 days. It is, however, essential that during the critical period—that is, from the 5th or 6th day,—the temperature should never exceed 65° and that the average, should be as near 60° as possible. If the seed obtained from the second generation is treated in the same way, we can make it hatch again, changing its nature from bivoltine to trivoltine; and so, for any number of times. Univoltine eggs, however treated, will not hatch in this way—and this nature is the peculiar characteristic of bivoltines.

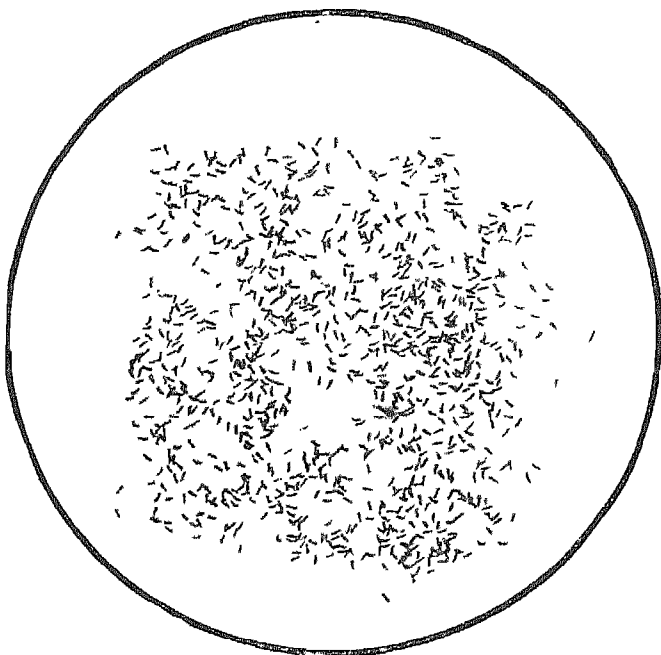
For the incubation of *polivoltine* worms, the most suitable average temperature is between 75° and 80° F. The fluctuations should be kept between 70° and 85° F. If the average is lower than 75° or higher than 80°, or if the fluctuations fall below 70° or rise above 85°, the evil consequences already described will ensue. Even in *polivoltine* layings, some eggs may turn black and not hatch, owing to season, but by proper incubation as described under bivoltine eggs, this

result can be prevented. *A sudden fall in temperature or increase in humidity during the period of incubation causes an increase in the number of polivoltine eggs that turn black.*

The regulation of humidity during incubation is also important. If the humidity is too low, that is to say, if the air is too dry, a certain portion of the eggs do not hatch at all. The worms hatched are small in size, and remain small throughout the crop. Their development becomes ununiform. An unusual quantity of worms is lost in the rearing and the cocoons spun are also small and of inferior quality. Too high humidity is even worse in its consequences. The worms are very weak in reality, though looking plump and strong outwardly. They develop uniformly, but are fat and flaccid to the touch, and die in numbers during the rearing. They are also liable to disease. The cocoons spun, though large in size, will be loose in texture, and poor in silk content. The quality of these cocoons is not at all good.

What is the proper percentage of humidity? In regard to this point there is not the same difference between univoltine, bivoltine, and polivoltine races as with regard to temperature. The proper average humidity is between 70 and 75 per cent, and the fluctuations should not be below 60 per cent or above 80 per cent. Adverting to the temperatures given above as suitable for incubation, it may be roughly said that the average difference in temperature between the wet and dry bulb thermometers should be 5 or 6 degrees; the maximum difference (when the air is dry) should not be more than 8, and the minimum (when the air is wet) not less than 4.

It is almost unnecessary to say that the room should be disinfected before incubation and that the air should be quite clean and free from dust. The room should be kept free from dirt, and care should



“ANTS,” OR NEWLY HATCHED WORMS
They are dark and appear hairy

be taken to preserve the seed from contact with any possible sources of infection.

In sericultural countries in the temperate zone, the maintenance of the correct temperature and humidity is easy, as it is most commonly necessary only to increase the warmth by a fire or stove. In India, on the other hand, it is more often necessary to lower the temperature, and this requires rather elaborate arrangements, which are outside the ability of most rearers. Therefore the incubation of univoltine and bivoltine eggs is a matter which can only be taken up by well-equipped grainages. Fortunately here, practically only polivoltine races are reared and the incubation of these is not such a difficult matter. The coolest room should be selected and maintained as cool as possible. If the air is too dry, water may be sprinkled on the floor and walls, or a wet cloth may be kept below the receptacle containing eggs, or disposed above so as not to touch the eggs. Or open, shallow dishes containing water may be kept in the room so that evaporation might supply the necessary degree of humidity. A small room is preferable to a big one, as in it the temperature and humidity can be more easily controlled. The room should also not be exposed to draughts of air, or radiation from the sun.

BRUSHING

Brushing is the process of separating the newly hatched worms from the shells of their eggs, by means of a feather, and collecting them for convenience of rearing. There are many methods of brushing, according to the condition in which the eggs are obtained, as eggs may be loose grains purchased by weight, or layings sticking as they are deposited by the mother moth on cards or papers.

In the case of loose eggs, the most usual and convenient method is as follows:—Eggs are spread

evenly in one layer on a flat tray, and when they change colour preparatory to hatching, they are covered lightly over with a thin cloth, or fine meshed net, or finely perforated and thin paper. This covering just touches the upper surface of the eggs. Just before brushing, finely chopped mulberry leaves are sprinkled on the top of the net or cloth or paper—not for the worms to eat, but just to attract them to crawl on to the under surface. It is convenient to have the net or cloth or paper stretched on a frame which is of a size to just fit the tray in which the eggs are kept, in order that the active newly hatched worms might not crawl out, and get lost. When a sufficient number of worms have hatched out, the rearer takes out the cloth, and collects the worms which have crawled on to it with a feather in a tray and proceeds to feed them. Or he may give them their first feed on the cloth or net itself, and remove them to the tray afterwards. What is a sufficient number depends on the convenience of the rearer, and also on the climatic conditions. Supposing the air to be cool and not too dry, the brushing may be delayed without danger for a much longer time than when the air is hot and dry; for in the latter case, the newly hatched worms would get too weak and may even wither up if not collected and fed soon. On the other hand, brushing too soon will result in inequalities in the worms hatched, and some of the eggs may not even have hatched. In the case of free eggs bought by weight specially, it is but seldom that all the eggs hatch in a day, and brushing may have to be done more than once, and too early brushing will result in the rearer having to attend to several batches of different ages which would be a great inconvenience. The point to aim at in brushing is to get as large a number of worms at each brushing as possible, and to have as few brushings as possible.

In regard to eggs which are purchased as layings on cards or on paper, as in Mysore, there are several

methods of brushing; of these, the most convenient are (i) by tapping, (ii) by feather, (iii) by cloth or paper or net, (iv) by direct feeding, (v) by husk and feeding, (vi) by net and feeding. Each of these will be briefly described.

To start with, the egg card or paper, when the eggs change colour preparatory to hatching, should be covered with a large sheet of paper to prevent the active young worms from crawling out and getting lost. It must be noted that the newly hatched Mysore worms do not display the same aptitude to stray as worms of other varieties.

In brushing by *tapping*, the egg card on which the worms have hatched is taken up, and the worms which have crawled on to the margins and corners are first gently brushed on to the covering paper. Then the card is held face down at a distance not exceeding a foot above the paper, so that the layings are on the under surface, close to the paper. The rearer next administers three smart clean taps on to the top, so as to shake the hatched worms from the card on to the paper below. Care must be taken that the taps are clean and hard, so that the impact is enough to shake the worms completely off the card. Three taps properly distributed ought to be quite enough. If the taps are feeble or indecisive, all the worms will not fall off, and some of them will be left on the card, or found hanging therefrom on filaments of silk. This process, once the right knack is acquired, is the cleanest and most satisfactory method of separation. The worms may then be gathered up with a feather and weighed—the object of weighing being to get a correct estimate of the leaves, space and labour, required for the crops—and are then spread out conveniently on a tray and fed.

In brushing by *feather*, the card or paper is held vertically by one end over the paper and the worms are separated by means of gentle strokes with a feather. They are then weighed and treated as above. This method is simple and easy, but is apt to injure the

worms, which at this stage are extremely tiny and delicate.

Brushing by *paper* or *net* is an adaptation of the method described in relation to loose eggs. The layings are covered over with paper or net or cloth, and the worms which crawl on to the under side are collected, and treated as described above.

Brushing by *direct feeding* is spreading finely chopped mulberry leaves on to the card or paper on which eggs have begun to hatch, so that the newly hatched worms crawl on to the top of the feed. This method is simple, but is open to some objections. As all worms have not hatched out at the same time, the earlier ones naturally have more appetite and eat more than the later ones, and this gives rise to inequalities of development which are a fruitful source of future trouble. Moreover, in this method, it becomes impossible, or at least extremely difficult, to determine the exact weight of the worms. It is possible to arrive at this indirectly, by weighing the egg cards or paper before hatching out, and deducting from this weight, that of the egg cards with the empty shells; or by weighing mulberry leaves by themselves before feeding and weighing them with the worms on them—but neither method is accurate or satisfactory.

The method of cleaning by *paddy husk* and *feeding* overcomes the first difficulty, namely, that of inequality arising from different feeding; but the difficulty of weighing remains. In this method, the egg card or paper on which the worms have begun to hatch out is sprinkled over evenly with a thin layer of finely pounded paddy husk. The young worms rise through this layer of paddy husk and collect on the top. When a sufficient number have come, they are given a feed, and then collected and transferred to a rearing tray. In places like Mysore, where it is not usual to weigh newly hatched worms, but an estimate of requirements is based on the

number of layings, this method may be most conveniently adopted.

Brushing by *net* and *feeding* is very similar to the last and differs only by the employment of a fine meshed net, instead of paddy husk.

It may be said that the number of layings is a very unsafe standard for calculating the requirements of a rearing. The number of eggs laid by a moth is subject to large variations due to individual peculiarities or health, and difference in race, season of the year, and so forth. For instance, a Mysore moth may ordinarily lay anything between 300 to 400 eggs and the margin of error is sufficiently large to make the rearer's calculations wrong and cause him serious loss. Weighing newly hatched worms avoids this error by giving an indication of the actual quantity of worms to be reared.

It must be noted that silk-worm eggs generally begin to hatch at daybreak, and that the hatching progresses till noon, and that after that, with a few stray exceptions, the eggs that are left unhatched remain so till the next daybreak. The result is that on any day, by far the largest part of the day's hatchings will have taken place before noon; and it would be unwise to allow these newly hatched worms to remain uncared for to await the scanty afternoon hatchings. *The best time to brush would therefore be just before noon*; and this should be borne in mind.

It frequently happens that all the eggs of a lot do not hatch on the same day. It is easy to see that two batches of worms which differ in age by a day must be a strain on the rearer, as he can have no respite from work even during the moulting periods. Where one of these batches is small, much the best course would be to reject it. But what if the batches are both large, as sometimes happens?

Mysore practice, in such a contingency, is not uniform, but varies with the circumstances and temperament of the rearer. One with optimism, aided

by a plentiful supply of mulberry, and a numerous and industrious household, might elect to rear both batches of worms. Another with more limited resources, or a less buoyant spirit, might reject the batch which to him appears the smaller or less promising. The one knowingly accepts trouble believing he can cope with it; the other reluctantly sacrifices a part because "half a loaf is better than no bread;" but both would be glad of some way which could avoid both trouble and loss.

One way is to speed the growth of the later worms, and thus enable them to catch up the earlier ones by the time they reach the third moult. If this is done, the difficulty is practically solved, as the real hard work in the rearing room begins after this stage.

We have seen that warmth, within certain limits, stimulates vital functions, and that food builds up body tissue. Advantage is taken of both these influences to hasten the development of the later worms. They are kept at a slightly higher temperature—just the difference that is made by a higher shelf or a warmer room—and given an extra feed or two every day. The object in view could be more easily secured by retarding the earlier worms a little by delaying to feed them for a few hours after they came out of each moult; but this is not recommended. This method requires an appreciable increase in care and work.

Another, and perhaps better expedient, is to stimulate the eggs so that they all hatch at the same time. The egg sheets are spread out on a piece of paper in the rearing tray and kept, as far as possible, under similar conditions as to temperature, etc. A day before they are due to hatch—a fact indicated by their turning dark—they are lightly and evenly stroked half a dozen times with a soft brush or feather. This treatment is repeated throughout the day at intervals of about three hours. Early next morning, any worms which have come out are gently removed to a sheet of paper, and the unhatched eggs

are brushed as before, but at shorter intervals. By about 3 P.M. about 95 per cent of the eggs will be found to have hatched. The other 5 per cent may be neglected without much compunction.

After brushing, attention has next to be bestowed on the food and care of the young worms. The young worms require very tender leaves. In selecting tender leaves, the top buds of new shoots and the leaf next to them should be avoided ; the best leaves are the third, fourth and fifth tenderest and topmost leaves of new shoots. These leaves will not be buds or half opened leaves, but though fully formed, they will still be tender and yellowish red. Coarse leaves should be avoided. It must be remembered that at this stage, the worms do not require a large quantity, but that what they get should be absolutely suitable and sufficient for them. They are as apt to suffer and die at this stage as at any other ; only as they are so tiny, their individual deaths pass unnoticed, but a gradual diminution is observed. It would be very false economy to save leaves or care at the cost of insufficient nutriment or disease.

The worms at this stage should be kept at a temperature slightly higher than that prevailing at the time, so as to stimulate their appetite and vital functions. Too high a temperature would mean rapid drying up of the tender and finely chopped leaves, and insufficient nutrition of the worms. At a time when the average temperature is 74° or 75° F, 76° or 77° F would be a very suitable temperature for the young worms. Too great humidity should be avoided as the beds should be kept clean and dry. Changing beds too frequently would result in injuring the tender worms and a number of worms will inevitably get lost at the time of each change, and beds can be kept clean for a long time without changing, only if the air is not too damp.

Direct exposure to draughts or sunlight is also very harmful, and should be avoided.

CHAPTER IV.

Harvesting and Storage of Mulberry Leaves.

HARVESTING OF LEAVES.

THE leaves of the higher plants, of which mulberry is one, contain chlorophyl. They assimilate food during the day in the hours of sunshine, for distribution to the other parts of the plant in the form of carbohydrates, proteids and fat. As the distribution in the day is comparatively small, it would seem to follow that the weight of a leaf should be greater during the day than at night, but as a good deal of water passes out by evaporation at the same time, the increase of weight is very slight. It has been experimentally determined that the bulk of the products of assimilation consists of carbohydrates and fat. The following table shows the carbohydrate content at intervals of 3 hours in percentages of the total weight of leaf, for six well known Japanese varieties of mulberry, and is based on the results of careful analyses conducted in Japan :—

Variety of mulberry	5 A.M.	8 A.M.	11 A.M.	2 P.M.	5 P.M.	8 P.M.	11 P.M.
No. 1	6'4	7'1	8'0	8'5	7'8	7'6	...
" 2	6'3	6'3	7'3	8'1	8'4	7'1	...
" 3	7'3	8'5	8'9	9'5	8'9	8'8	...
" 4	7'0	7'2	9'1	10'5	...	9'5	...
" 5	8'5	8'8	10'1	10'1	11'1	9'5	8'6
" 6	9'3	9'9	11'1	11'8	11'6	11'1	10'7

The meaning of the figures is perfectly clear. The proportion of carbohydrate increases gradually

from dawn, till it reaches its maximum at 2 P.M. This maximum is maintained till about 5 P.M.; after sunset a very rapid decrease takes place till about 11 or 12, when the weight is very close to the minimum. The process of translocation continues, though imperceptibly, and the minimum is reached at dawn. The water content of the leaves begins to increase after sunset, and almost reaches its maximum weight at about midnight. The increase is maintained by very slight degrees, and the maximum is reached at dawn. After dawn the water content slowly goes down, as the solid contents increase.

Since the composition of the leaf varies at different hours of the day, and carbohydrates are quite essential for the development of the silk-worm, it is important to select the right time for plucking leaves. The best time is the evening, when the leaves are richest in food matter and the worst time is the morning, when they are poorest. It should be borne in mind that it is not enough to pluck the leaves at the proper time—it is equally essential to preserve them without deterioration, by taking proper precautions to prevent them from withering or fermentation. The precautions to be adopted will be described in detail in a subsequent section.

There are three ways of harvesting leaves, (i) by cutting branches with the leaves on them, (ii) by removing the shoots, and (iii) by picking the leaves. The quality of the leaf depends on the manner in which it is harvested and each of the methods described above has its own advantages and disadvantages, and each may be considered suitable to one particular season.

Cutting branches with leaves, is generally done when it is considered desirable to prune the garden, once a year, and also when it becomes necessary to thin out side branches to secure better growth and ventilation. Cutting branches is most frequently done as part of the management of the garden. Leaves

on cut branches remain fresh for a comparatively long time; and feeding them to worms as they are, saves labour in the rearing room. In countries where the cost of labour is very high, they are obliged to have recourse to this method of feeding; but from other points of view, this is not very desirable. The quality of the cocoons suffers owing to the leaves deteriorating through their nutrients (including carbohydrates) gradually passing on to the stem. In this method also, worms do not get the detailed attention which is good for them.

Gathering leaves by removing them with the shoots requires less labour, no doubt, than picking the leaves separately, and is sometimes employed on that account—but that is about its only advantage. For one thing, it is impossible to get only leaves of the proper degree of maturity, as too tender leaves get mixed up with more developed ones; and for another, the least carelessness will injure the plant and diminish its output.

Picking leaves is the best method of harvesting, but it requires more labour. As separate leaves dry sooner, a larger number of feedings is also necessary in the rearing room. In countries where the cost of labour is low, or where the rearer's family itself supplies the labour, as in Mysore, this method can be adopted with advantage, as the results of rearing will amply repay the increased trouble. There are three ways in which leaves can be picked. The leaves can be plucked with the stalk entire; or the stalk may be cut midway, one half of it going with the leaf, and the other half remaining on the plant; or the entire stalk and a part of the base of the leaf may be left on the plant, by cutting off the leaf a little above the stalk. The first method is the easiest and quickest but there is the danger of injuring the accessory bud. The next is a little slower and requires greater care, but saves the bud from injury. The third is most laborious and slow, but is best from the point of view

of the tree, as the little portion of leaf left on the stalk continues to function and feed the tree; but the advantage seems not sufficiently pronounced to justify the greatly increased labour involved; moreover, the leaves removed in this way are very easily spoiled for feeding purposes, especially in the dry season.

From no point of view can the method which prevails in some parts of the Kolar District of cutting down closely planted mulberry several times in the year and feeding them to worms be defended. The mulberry leaves thus got are diminutive, and very poor in quality and the worms reared on them are feeble in health and produce poor cocoons. This probably explains why the cocoons produced in that area are considered unfit for seed.

STORING OF LEAVES.

The best condition in which mulberry leaves could be fed to silk-worms is immediately after they are picked from the plant, when their constituents are wholesome and in an ideal state for assimilation. After being plucked, they, in course of time, undergo a gradual alteration which injures their nutritive qualities. The most obvious change is loss of water—which is due mostly to evaporation, but also partly to utilisation for helping in the internal chemical changes. The most important alterations are those which take place by chemical action among the constituents of the leaf. The change which most affects the nutritive value is the breaking up of the proteids. The most striking loss is that of carbohydrates, which are used up for the vital functions of the leaf which continue long after it is plucked. This loss, therefore, occurs even when the leaf is kept in a fresh condition. It has been experimentally ascertained by Mr. Katayama that mulberry leaves, even when kept at a low temperature in air at the point of saturation, lose 10 per cent of their weight, though

continuing to all outward appearance, perfectly fresh. The loss is contributed by water and other constituents approximately in the proportion in which they existed in the leaf. Of the dry constituents, carbohydrates were reduced by more than 50 per cent, while the others suffered only a very slight diminution. When mulberry leaves were kept in an atmosphere of the natural condition (70° F temperature and 80 per cent humidity at time of experiment) their weight decreased rapidly and the decrease was mostly due to loss of water. The loss of water was nearly 50 per cent in the course of a week, while the loss of dry matter was about 10 per cent during this period.

Leaves, immediately after they are picked, are, as we have said, in an ideal condition for being fed to silk-worms, but unfortunately this is not a condition in which they can always be utilised in practice. It is necessary to pluck leaves and store them for future use; and we have to enquire into the best method of storing them, and preventing them from deteriorating by storage.

The most important points to remember are these:—

1. *The period of storage must be as short as possible.*—As has already been explained, leaves are constantly losing weight, and getting injured by internal chemical changes during storage.

2. *A low temperature and a high humidity are preferable for storing leaves and these should, as far as possible, be obtained.*—A high temperature stimulates the vital functions of the leaf and also hastens the changes in composition. If the humidity is low, the loss of water by evaporation is greater and not only is there much loss of weight, but the balance in composition is also altered. A saturated condition of air—that is, 100 per cent of humidity—would be an ideal condition. High temperature changes the composition of the leaf whereas low humidity disturbs the

balance of the composition by altering the proportion of the constituents, and thereby injuriously affects the food value of the leaf.

3. *The rays of the sun should not be allowed to fall on the place where leaves are stored.*—Sunlight stimulates the vital functions of the leaves; the heat of the sun, besides causing the leaves to wither, also sets up fermentation.

4. *Draughts should, as far as possible, be excluded.*—This precaution is necessary to preserve the essential conditions of low temperature and high humidity. A free current of air, it is needless to say, hastens evaporation and consequent withering up of the leaves.

5. *Mulberry leaves should not be heaped up high and should, under no circumstances, be packed closely.*—If they are packed into a tight heap, fermentation sets in and heat is generated in the middle of the heap, damaging the quality of the leaves very seriously.

For the benefit of rearers who can afford to have a separate room for storing leaves, we give below a specification of the details which would satisfy the above conditions, as far as possible. Even to those who must be content with such accommodation as they possess, these details would not be without interest and profit as they would enable them to select the best room at their command and suitably adapt it for storage of leaves.

The room intended for storing mulberry should preferably be wholly, or at least partially, below the level of the floor, and should be plastered with cement inside. It should be filled with racks for holding baskets containing leaves, which may be rectangular, and about 4 feet $\times$ 3 feet $\times$ 10 inches in size. The door should be to the north to obviate chances of hot air coming in, and should be provided with shutters which close it completely, so as to exclude air. It would be best to line the inside of

the shutters with cloth or flannel. The roof should be provided with windows for light, and to facilitate the renewal of air, when necessary; for it should be remembered that, though draughts are harmful, absolute stagnation of air is equally bad, as it would favour setting in of fermentation. The leaves should be filled loosely into the baskets, and covered with a wet cloth or mat and the baskets should then be kept on the rack. When the climate is hot and dry, a wet cloth or mat may be hung on the front of the rack also, and water may be sprinkled on the floor of the leaves room or cellar. In Japan, it is not unusual to have the floor quite running with water, so that one has to walk on a bamboo mat to get to the racks. It must be remembered that an absolutely saturated atmosphere is best for the leaves. As too much humidity is bad for silk-worms, it is necessary to keep the leaves in a place different from the rearing room.

With perfect arrangements like those indicated above, there would be no fear of fermentation of leaves; but under the conditions which usually prevail in practice, a few simple directions might be useful to rearers. Instead of keeping the leaves in a big closely packed heap, it would be better to keep them in a series of small conical heaps of about a foot and a half in height; or in a series of lines about a cubit in height, and stretching in rows across the room. These lines may be a cubit broad with sloping sides of the same breadth which meet at the top, so that the section will be a triangle with equal sides. A third way is to spread the leaves lightly on a mat or chick, and roll the mat or chick loosely, so that there is a layer of leaves between the folds of the roll. This roll may be kept leant against the walls of the room. In the earlier stages of rearing, when the quantity of leaves required is comparatively small, and their quality very tender, a good plan would be to keep them in a basket or pot, which is placed on a

bed of clean sand which is maintained constantly wet with water. When, with the progress of the worms, a greater and greater quantity is required, it would still be good, as far as possible, to keep the leaves in a number of pots or baskets on wet sand ; when the quantity becomes too large for the continuance of this arrangement, any of the other methods described above may be adopted.

CHAPTER V.

Preparation of Leaves for Feeding.

THE best way of preparing leaves for being fed to silk-worms is to chop them into convenient sizes. The advantage of chopped leaves is that, in that condition, they can be distributed evenly to the worms, and that the quantity fed can be easily and accurately regulated. Chopped leaves prevent the silk-worm bed from getting damp in wet weather, and they also do not curl up when the air is hot and dry. If entire leaves are fed, they curl up when they dry and sometimes enclose young worms which thus get lost. Chopping leaves has its disadvantages also. There is the cost of labour required in cutting and there is naturally also some loss in the process of chopping. Cut leaves dry sooner than entire leaves, and therefore there is a greater amount of waste in feeding. But weighing the advantages against the disadvantages, the balance is greatly in favour of chopping.

There are three methods of chopping, which differ from one another according to the shape of the chopped leaves—the square, the oblong, and the triangle. The square method is best when the air is dry, and it is necessary to prevent the chopped leaves from getting dry soon. As withering takes place from the cut edges and progresses towards the centre, it is obvious that the shape which presents the smallest length of edge, and of which the centre is farthest from the edge, is best fitted to resist drying, and the square satisfies these conditions. Long thin strips or oblongs are suitable when the season is wet. Leaves are cut into triangular pieces to save labour, when in the

advanced stages of a rearing, a large quantity of feed has to be prepared.

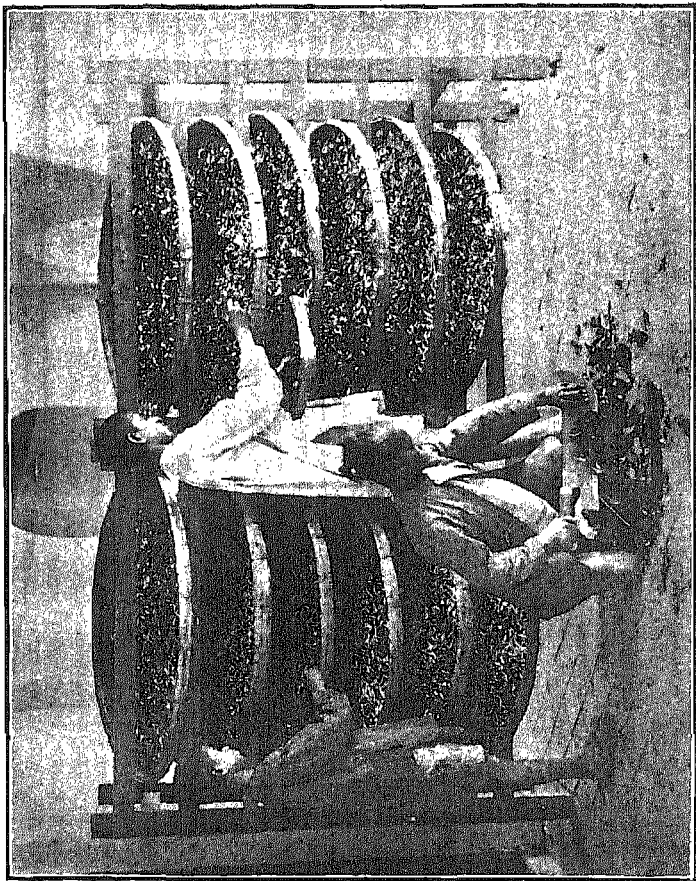
The practice of cutting tender leaves into very fine strips for *chawki* worms even in hot weather is irrational, and should be abandoned.

The size of chopped leaves must be regulated according to the condition and size of the worms. As a rule, the size of the worm should be taken as the standard, and the leaf should be chopped into pieces the surface of which is equal in extent to the square of the length of the worm. Thus, supposing the worm is one inch long, if the square method is adopted, the chopped pieces should be 1 inch $\times$ 1 inch; if the oblong method is adopted, the size may be $\frac{1}{2}$ inch $\times$ 2 inches or $\frac{1}{3}$ inch $\times$ 3 inches, so as to give an area of 1 square inch. If the triangular method is adopted, the side should be slightly more than an inch, and so on.

This standard has sometimes to be modified a little under special conditions. When the weather is dry and hot, a slightly larger size, and when, on the other hand, it is wet, a slightly smaller size than the standard, would be preferable for obvious reasons. When the bed has to be changed and the feeding has to be given on a net, a slightly larger size would be advisable, to prevent the chopped leaves from dropping through the meshes, or blocking the meshes so as to obstruct the rising of the worms. When, for the purposes of the rearing, it is required to have a dry bed, smaller sizes ought to be used. The size may also be varied according to the appetite of the worms, a larger size being used when the worms eat voraciously, and a smaller one when they have not much appetite and the feed has to be more evenly regulated.

A few practical hints about the process of chopping leaves may not be without use. The leaves must be placed on the chopping board, preparatory to cutting, as far as possible, in regular layers. If they are placed anyhow, some of them will be one way and some another, some will be folded and some curled

or rolled up, and the knife in cutting through the mass will produce all sizes and shapes of pieces. It becomes impossible to regulate the size. On the other hand, taking the leaves one by one and carefully arranging them one over the other is extremely wasteful in labour, and too much handling with the warm fingers spoils the leaves, especially if the leaves are tender. The best method would be to sprinkle the leaves from a height of 2 or 3 feet on to the chopping board, by handfuls so that each handful falls flat in an even layer on the board. Several handfuls may be thus sprinkled till the required quantity lies on the board, and then this may be gathered up evenly, pressed with the hand or a flat board and cut. For cutting the finer sizes, a smaller quantity of leaves should be taken at one time than for the larger sizes. If the mass to be cut is too high, fine cutting cannot be evenly done. A broad knife is favourable for clean, even cutting. A narrow one does not cut true, and a blunt one bruises the leaves. A common practice in villages is to *saw* forwards and backwards with a blunt knife instead of cutting. This crushes and bruises the leaves. The proper way is to use a sharp knife, and to cut with an even, drawing motion towards the cutter. The size of the knife should be suited to the size of chopping and at least two sizes of knife should be kept. In case it is desired to have the sizes quite uniform, the chopped leaves may be passed through a sieve of suitable mesh. In the later stages, a winnow may be used for separating pieces of stalk or other solid matter from the chopped leaves.



CHOPPING LEAVES AND FEEDING

CHAPTER VI.

Feeding.

QUANTITY OF FEEDING.

FEEDING is perhaps the most important factor in rearing; for it has a direct connection with the development of worms on the one hand, and with the cost of rearing on the other. The ideal in feeding is to administer nourishment to all the worms simultaneously and equally, and thereby to secure uniform development; and while giving them enough to eat, to prevent wastage in any way. It is important to get an idea of the proportion utilised in building up the body tissue of the worm, out of the total quantity consumed by it, so that by knowing the normal development of the worm, we might fix the correct quantity of food to be given. We know that the worms develop very rapidly from age to age, increasing to several times their original weight and size in each age. The weight of leaves they require for food during each age is roughly $2\frac{1}{2}$ times their increase in weight from the 1st to the 4th age; but in the 5th or last age, they consume about $4\frac{1}{2}$ times the weight of their development in body. The increase in weight of worms during the rearing varies with the race and the season, but is approximately—

15 times	...	from hatching to end of
		1st stage
4 to 5	do	...
		during 2nd age
5	do	...
		do 3rd age
5	do	...
		do 4th age
5	do	...
		do 5th age

so that, roughly, the weight of the full grown worms will be from 7,000 to 10,000 times that of the newly

hatched worms. Ordinarily the newly hatched worms from 100 layings of the Mysore race weigh about $\frac{3}{4}$ tola.

From these data, it is easy to calculate the total quantity of leaves which will be required for actual consumption for rearing a given quantity of worms.

The above gives the approximate quantity of actual consumption—the quantity eaten by the worms. The quantity to be fed has necessarily to be much more than this, as we have to allow for diriage during the time that the worms take to feed. The worms do not eat continuously, but alternate between eating, rest, and moving about in search of food to their liking, and so they take a long time to consume their feed; and all this time the chopped leaves are drying, and portions of them are getting unfit for food, especially in hot and dry seasons. During the first age specially, this discrepancy between the quantity of leaves fed and that consumed, is specially great as the young worms feed for a comparatively small part of time, and the leaves, being tender and finely chopped, are drying rapidly. During this stage the worms develop from 14 to 15 times their original weight, and therefore the quantity of leaves to be fed is very great. As the worms develop, the portion of their time that they devote to eating continues to increase, till in the 5th age, the greater part of it is spent in that way. As the age of the worms advances, the leaves fed to them are more mature and less apt to dry, and the chopping also is in larger sizes—all circumstances which tend to decrease the proportion of waste and increase the proportion of actual consumption.

The result is that in practice the quantity of leaves to be fed has to be calculated by adopting different multiples of the development during each age, as below :—

During 1st age	...	7 times the actual increase in weight of the worm.
----------------	-----	--

During 2nd age	...	3 to 4 times the actual increase in weight of the worm.
Do 3rd age	...	2 to 3 times do
Do 4th age	...	1½ to 2 times do
Do 5th age	...	1½ times do

It is, no doubt, possible to save leaves by feeding more sparingly ; but this can only be done at the cost of development. The worms would suffer most from underfeeding during the earlier ages ; and as the absolute quantity of food they require is small, it would be very false economy to save out of their food. In fact, much of the cost of rearing during these ages is in labour, and the future results depend, to a large extent, on the health and condition of the worms during this period, when their development is very rapid.

The figures given above are not fixed but are subject to variation according to the conditions which prevail during the rearing. These are :—

1. *Quantity of leaves.*—This differs with the kind of mulberry plant, its cultivation and seasonal conditions upon which depend the structure and composition of the mulberry leaves ; and these again have a bearing on the slowness or rapidity of withering of the leaves, and their nutritive value.

2. *The time of plucking leaves and method of plucking.*—Leaves plucked early in the morning or late in the evening are slower in drying than those plucked during mid-day. Leaves which are cut at the base, leaving a small part on the stalk, are apt to wither rapidly.

3. *Duration and method of storing.*—Even with the most careful storing, the leaves will be always losing water, and this loss of water hastens further diriage. If the storing is imperfect, the nutritive value having been already damaged, a larger quantity will be required.

4. *Way of chopping.*—The size and shape of the chopped leaves have much to do with the time taken for drying. Finely chopped leaves dry sooner,

and feeding has therefore to be more frequent. It has already been seen that square pieces remain fresh longer than narrow strips.

5. *Temperature*.—The quantity of leaves to be fed varies also with temperature. A high temperature stimulates the appetite of the worms on the one hand, and hastens the drying up of leaves on the other, and both these causes render a larger amount of feeding necessary.

6. *Humidity*.—The rapidity with which leaves wither has a direct and obvious connection with the humidity of the air. When the air is dry, the leaves wither rapidly and a large quantity of feeding is necessary. When it is wet, the leaves remain fresh for a long time and the feeding can be appreciably reduced. Ordinarily, that is, leaving extreme cases out of consideration, the appetite of the worms increases with dryness.

7. *Way of feeding*.—The worms may be fed more frequently with less quantity for each feed, or less frequently with a larger quantity at each feed. It is more economical in leaf, though obviously less economical in labour, to feed a large number of times with a small quantity each time, than to feed a large quantity each time, but less frequently.

8. *Nature of worms*.—Different races of worms differ greatly in activity, some being very active and others comparatively dull. The former eat vigorously, and the proportion consumed is relatively high, and that wasted, relatively low. The total amount of leaves required for a rearing with a given quantity of these worms will be comparatively smaller than for one with the duller varieties.

The general considerations detailed above will enable the rearer to work out the quantity of leaves required and the frequency of feeding and the quantity to be given at each feeding; but as he has to deal with conditions which are proverbially variable, he must know how to modify his feedings suitably.

A careful observation of the silk-worm bed will furnish valuable hints in this regard. Suppose the bed is damp and a large quantity of yet fresh leaves remains unconsumed, he will feed less frequently and chop the leaves finer. Supposing the leaves have withered up too soon, he will give more frequent feeding and increase the size of the chopping, and so on. The progress of the worms in each age also furnishes a very valuable indication of the quantity to be fed. At the beginning of each age the worms have a great appetite. This appetite falls off very rapidly in the first part of the age and then goes on gradually increasing till close to the end of the age, when it again declines as the worms reach the moulting time. The feeding should be suited to this appetite variation, as otherwise there would be a waste of leaves when the worms' appetite is dull, and not enough food for them when they are in the hungry phase. A judgment can also be formed on the appearance and behaviour of the worms. Looking on a tray of worms as a whole, if the worms are very active in their movements, their appetite is keen and they require more food. If, on the contrary, they are still and dull, they do not require so much food. Looking at individual worms also, one might derive useful hints—of course, after the worms are sufficiently developed, for very young worms are difficult to observe and are changing frequently. When the worm is of a rusty colour, having recently come out of moult, it is very hungry. As this rust decreases, the appetite declines; later on a blue tint appears at the segments, which gradually spreads over the worm, growing in intensity. This tinge is an indication of returning appetite and the appetite grows steadily, till a whitish colour mixes with the blue, when it reaches its maximum. Thereafter, the worm takes on a light amber colour preparatory to moulting and this marks the period of a rapid falling off in appetite. Another way of looking at the worms is

this:—Directly they come out of moult and their new skins are still loose, their appetite is small. As they develop in length and present the appearance of worms long in proportion to their thickness, their appetite is great and they require much food. Then they go on getting stouter and by the time they have reached their maximum stoutness without decrease of length, their appetite has reached its maximum keenness. Then finally, after reaching their full stoutness, they shrink in length and their shape becomes, on the whole, cylindrical and it is a sign of decreasing appetite.

NUMBER OF FEEDINGS.

The frequency of feeding during the rearing can be regarded from two points of view—one, that of economy (both of leaf and labour) and another, that of health and strength of the silk-worm. The second point, which, in the long run, is not very different from the first, requires a close observation of the habits of the worm in feeding. The worm does not eat at one stretch, but in instalments, preceded by movement and followed by a short rest. It first moves about, obviously in search of food to its liking, then it eats for a while, and then it rests for a little; presently the movements commence again, followed by another brief act of eating, and another short spell of rest. The process of feeding then consists of a series of brief periods of alternating movement, eating and rest. After this series of acts and short rest have resulted in the satisfaction of the worms' appetite, there is a much longer period of rest, which differs from the short intervals which go hand in hand with eating, not only in its being much longer, but also in its being something closely akin to sleep. They go into this longer rest after their hunger is satisfied, and they awake to their usual movements (alternating with eating and rest) when

they get hungry again. This is their normal daily life during all ages; only in the earlier ages, the sleep (as we shall call the *long* rest to distinguish it from the brief intervals between instalments of eating) is comparatively shorter than in the later ages. In the 5th age, the worms may sleep from half an hour to an hour at one time.

From what has been said above, it will be readily seen that the best and most scientific method of feeding the worms would be to give them a fresh feed each time they wake up from sleep to another course of eating activities. But this requires very close and skilled attention, much labour, and a much larger number of feedings than can be given in commercial rearing. The best method is that which achieves a happy mean by reconciling practical economy with the scientific ideal.

- A practical adjustment is rendered possible by the fact that the mulberry leaves fed to the worms remain fresh for a much longer period than the time taken by the worms for one complete cycle of eating operations followed by the long rest or sleep described above, though the quality of leaves might suffer a slight change. While the ideal is to give a feed at each awakening, there are practical difficulties in the way of this being done. One of the most important of them is, as already stated, the greatly increased labour involved. Another is that *all* the worms do not go into long rest or come out of it at the same time. A third difficulty is that too frequent feedings might result in a damp bed, and though the leaves might continue fresh to all appearance, they would in fact be spoiled with the excretions of the worms, and with their weight and movements. So, generally, giving them a feed at the end of every second period of long rest would do very well in practice. The late risers would have fresh leaves ready for them. If the feed is given at the end of the third period of long rest, the previous

feed would already have become dry, and the worms would have suffered from insufficient nutriment. What has been stated above is the general rule; modifications will be necessary under variations of temperature and humidity. With a rise in temperature, the appetite of the worms becomes keener, and the leaves also become dry soon; so more frequent feedings become necessary. With increased humidity, there is a danger of the bed becoming damp and insanitary; the leaves remain fresh longer, and therefore less frequent feedings may be given.

To summarise. to give a feed at the end of each period of long rest would be too frequent; to give one at the end of every third period (or later period) of long rest would be too late, as the leaves of the previous feeding would have become unfit for food by then. Even if, owing to atmospheric conditions, the leaves in the latter case *appear* fresh, they are probably spoiled by excreta, and the trampling of the worms. Therefore, giving a feed at the end of every second period of long rest is the proper method.

The following working standard of the number of feedings to be given in a day in the different ages has been arrived at on a consideration of the facts given above, and as the result of long observation and experience:—

Age	Temperature 70° F Humidity 70%	Temperature 75° F Humidity 70%	Temperature 80° F Humidity 70%
1	7 to 8	8 to 9	10 to 12
2	6 to 7	7 to 8	9 to 11
3	6 to 7	7 to 8	9 to 11
4	5 to 6	6 to 7	8 to 10
5	4 to 5	5 to 6	7 to 9

It is needless to say that the above table is not meant for rigid application, but requires to be intelligently modified according to circumstances. A few of

the more important conditions, which necessitate a modification are given below:—

1. *Quality of leaves.*—When the leaves are tender, more frequent feedings are required as the leaves are liable to wither.

2. *Method of preparation.*—Square chopped leaves, and bigger sizes, resist drying more than other shapes and smaller sizes; so fewer feedings.

3. *Quantity of feeding.*—A thick feeding does not wither so rapidly as a thin one. So, if a large quantity is given at each feeding, the frequency may be decreased.

4. *Appetite of the worms.*—When the appetite is vigorous, the worms require a thicker feeding, as they continue to eat for a longer time. So, the quantity of each feeding may be increased, and the frequency decreased.

5. *Temperature.*—As indicated in the table on the previous page, as the temperature increases, the number of feedings should be increased. The worms have a livelier appetite owing to stimulated vital functions, and at the same time, the leaves are liable to wither sooner.

6. *Humidity.*—If the humidity increases, the appetite of the worms gets dulled, and they take longer to go into their periods of long rest; also the leaves keep fresh for a longer time; and so the number of feedings might be decreased.

In addition to these circumstances, regard must also be had to the methods of plucking and storage of leaves; and if these have not been good, the quality of the leaves will have been impoverished to start with, and so naturally, a greater number of feedings will be necessary. Modifications will likewise be required according to the nature of the worms, as some varieties are more active, and have greater appetite than others.

CHAPTER VII.

Cleaning.

CLEANING and spacing are next only in importance to feeding. Cleaning is quite necessary for the health and progress of the worms, as an unclean bed rapidly becomes a hot-bed of disease germs. Spacing is directly connected with the growth of the worms, and also with the regulation of the quantity fed at each time.

When it is remembered that ordinarily a much larger quantity of mulberry leaves has to be fed than is eaten up by the worms, it is obvious that a large quantity of unconsumed leaves, more or less in a state unfit for food, remains over in the tray at the end of each feed. In addition to this, there are the excreta, liquid and solid, which the worms are continually passing, and the whole forms a thick and often damp bed which ought not to be allowed to remain. The quantity of the unused and unusable surplus of mulberry leaves left over at each feed varies with the age of the worms and is approximately as below :—

1st age	...	80 to 90 per cent of the total feed	
			remains unused.
2nd age	...	70 per cent	do
3rd age	...	60 to 65 per cent	do
4th age	...	40 to 50 per cent	do
5th age	...	30 to 35 per cent	do

The quantity of the excreta passed by the worms has, of course, a relation to the quantity of leaves consumed by them, but its proportion to the latter is different in different ages. In the 1st age, the excreta are a little more than 50 per cent of the weight of the

food eaten ; in the 2nd stage the ratio is about 55 per cent ; in the 3rd, 4th and 5th stages it is between 60 and 65 per cent, rising gradually as the worm advances in age. The droppings contain a large proportion of water as the worm advances in the 5th age, and near the ripening stage they are quite moist and sticky, making the bed very wet, bad smelling, and dirty.

On the average, about three-fifths of the total weight taken in as food during the rearing is thrown out again as excreta, only two-fifths being assimilated by the worm. Besides hindering growth and forming a fruitful ground for the engendering of disease germs, an uncleaned bed has another disadvantage, especially in the earlier stages. When the weather conditions make the young worms sluggish, they are sometimes buried in the bed and get lost.

TIME OF CLEANING AND FREQUENCY.

From the standpoint of the health and sanitation of the worms, the more frequent the cleaning, the better it would be ; but in practice, there are important limitations. The labour involved is an obvious limitation—and it has also to be borne in mind that some worms, especially in the earlier stages, get lost at each cleaning. We have therefore to enquire—What is the number of cleanings absolutely essential for the health of the worms and what is the best time for conducting them ? These have to be fixed with reference to the age and condition of the worms, the temperature and humidity, the condition of the bed and other circumstances.

In the earlier stages, the total quantity of leaves fed is small ; the leaves are also tender and finely chopped, and liable to dry up soon ; and normally, in these stages wetness is not a source of danger and trouble. The young worms are also very tiny and very apt to get lost at each cleaning. It is therefore

necessary to clean only at comparatively long intervals, especially during the 1st age. As the worms advance in age, though the quantity of leaves left unconsumed at each feeding is a smaller proportion of the quantity fed, yet the absolute quantity remaining over unconsumed is vastly more. It has also been noticed that the quantity of excreta passed increases both proportionately and absolutely as the worms grow up. As the leaves are more mature and cut in bigger sizes, they also do not dry up and are apt to become damp in the bed. It is therefore necessary to increase the frequency of the cleanings as the rearing progresses. After brushing, the first cleaning may take place after the hairiness of the young worms disappears—after 2 to 3 days. If cleaning is done earlier, some of the young worms may get lost, and they are so delicate that they may suffer injury. The second cleaning may be done when they have just completed their greatest appetite period, look quite plump, and are preparing to go into the 1st moult. *Therefore 1st age—2 cleanings.*

In the 2nd age, after all the worms have come out of moult, the bed should be cleaned after two feedings. This cleaning should get rid of the accumulation of the 1st age and the remains of the subsequent two feeds and completely renew the bed. The second cleaning should be given about the middle of the 2nd age, just previous to the worms getting on to their maximum appetite. A fresh bed would stimulate the worms and give them a still keener appetite. The third cleaning should be given at the end of their appetite period, just as the worms are preparing to go into moult. Please note that worms prefer a dry bed for moulting on, and that they dislike a wet bed; so that moulting is delayed if the bed is old and damp. *2nd age—3 cleanings.*

In the 3rd and 4th ages, the first cleaning should be done after two feedings after all the worms have come out of moult. It is inadvisable to clean

before giving some feeding, because the body of newly moulted worms is very delicate and they may suffer injury by handling. Cleaning is also facilitated, if the bed is allowed to become a little thicker with two feedings. The second cleaning should be given when the appetite of the worms begins to increase. The third cleaning should be given just before the period of greatest appetite. The fourth cleaning should be given after the worms have finished the bulk of their feeding and are preparing to go into moult. *3rd and 4th ages—4 cleanings each.*

During the 5th age, the quantity of feeding given is very great and the bed is apt to get thick and damp soon. Frequent cleanings are necessary. On the day on which the worms come out of moult, clean the bed after two feedings. On all subsequent days, clean twice daily—once in the morning and once again in the evening. As the worms approach maturity, their excreta get moist and copious, and the more frequently the beds are cleaned, the better it is. A dry condition of the bed hastens ripening of the worms and a moist bed, on the contrary, retards it.

The temperature and humidity have also to be considered. When the air is moist the bed gets damp and the worms become sluggish and slow. If the air is moist and the temperature is also high, the bed is not only damp, but fermentation will probably set in. In these conditions, the bed should be changed much more frequently than indicated in the general rules given above. Damp bed and dull inactive worms are an indication which should never be neglected. If diseased worms begin to appear, the more frequently the bed is changed, the better it is for the rearing.

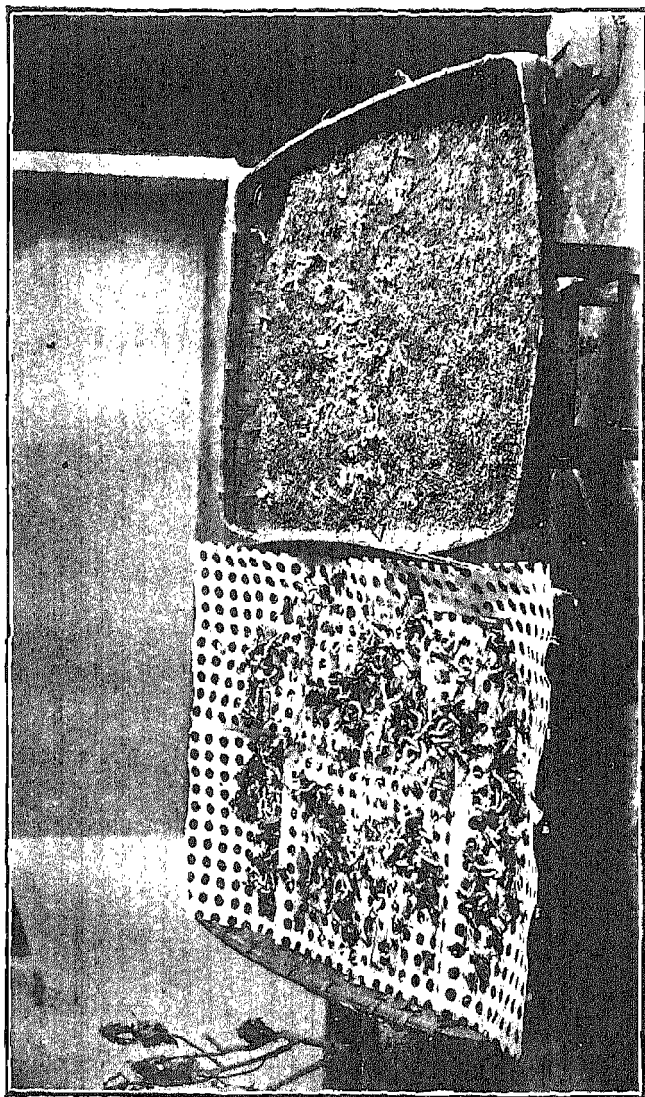
METHOD OF CLEANING.

There are *three* methods of cleaning, *viz.*, (i) cleaning with *husk*, (ii) cleaning with *net*, and (iii) cleaning with *husk* and *net*.

Method of cleaning with husk.—A thin layer of husk is sprinkled evenly over the bed, so that the whole is just covered. The worms rise up through the husk. Two feedings are then given, and the worms are afterwards swept up and gathered together with a feather brush over the layer of husk. It will be seen that the result of this method is immediately to separate the worms from their old bed and to give them a new bed over a clean, dry layer of husk. This is a great advantage, especially when the bed is damp in moist seasons. This method is specially convenient for subsequent spacing, for the worms having been gathered together, it is easy to redistribute them over the required number of trays. The only disadvantage of this method is that it involves slightly more work, not to speak of the small additional cost of husk.

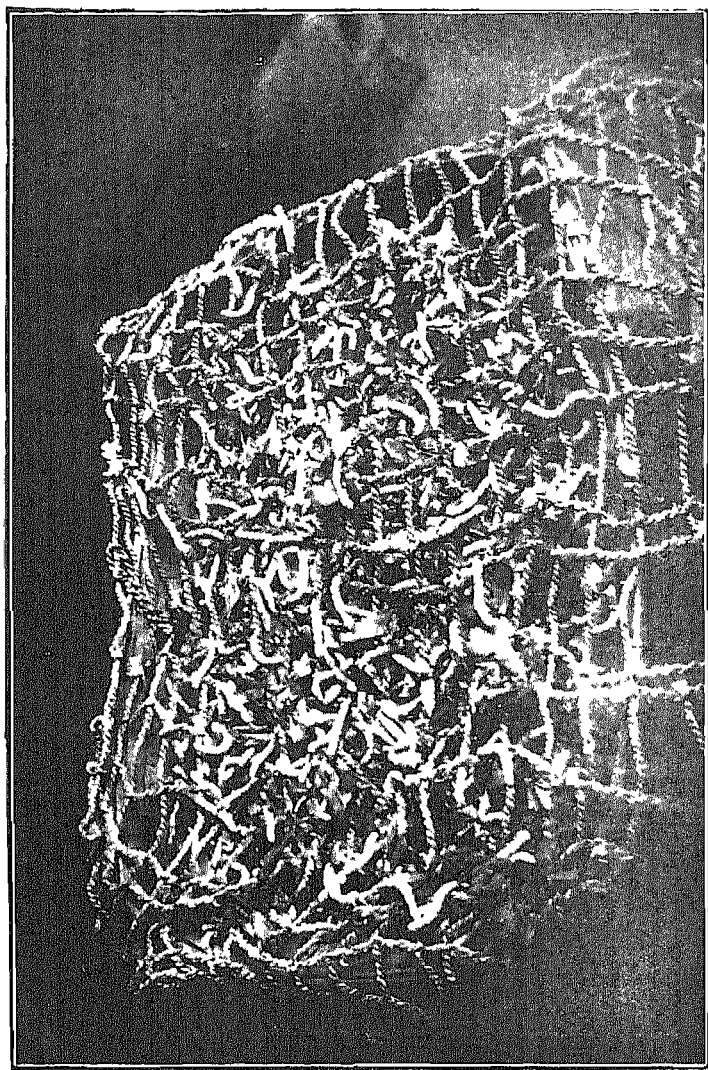
Method of cleaning by net.—A net of the proper mesh for the size of worms is laid over the old bed. Two feedings are then given with the result that the worms rise through the meshes and are separated from their old bed. The net with the worms on it is then carefully lifted from the old bed on to a new tray, and the process is complete. This method has the merit of being extremely simple, and requiring very little labour; but it is inconvenient for spacing purposes, as the new bed is necessarily of the size of the net itself. Another disadvantage is that portions of the old bed stick on to the net and are transferred with it to the new tray, so that the process lacks in the absolute cleanness of the husk method. Some of the worms also remain over in the old bed, if there are any eatable remnants of the previous feeding left. This is of very rare occurrence in the husk method, as the worms cannot continue to feed under the layer of husk, as they can in the comparatively free space below the net.

Combined husk and net method.—A thin, even layer of husk is first sprinkled over the bed and a net



USE OF PAPER NET AND OF PADDY HUSK FOR CHANGING BEDS

Left, paper net; Right, paddy husk



STRAW ROPE NET FOR CLEANING

of suitable mesh is superposed on it. Two feedings are then given on the net, and the net with the worms upon it is transferred to a new tray. This method combines the cleanness of the husk method, with the ease of transference of the net method, and requires less of skill and care in manipulation than the former; but it is more expensive than either, and it has the same inconvenience in regard to spacing that we noticed about the net method.

When husk is used, there are a few points to be borne in mind. Natural sized paddy husk is a little too big and too thick for worms in the first two ages, and so the layer becomes too thick and solid for the free passage of the worms. In these ages, therefore, the husk should be pounded and broken into small pieces before use with young worms. But care must be taken that it is not broken up completely into powder. In fact, husk powder should be carefully winnowed away from the broken husk before use. Husk powder is just as much dirt as dust and chokes up the worms and spoils the leaves fed to them. When the worms are in the 3rd age, there is no need to pound the husk; when they have passed the 4th age, chopped straw may be used instead of husk with advantage. Care should be taken, when the worms are young, that the layer of husk sprinkled is thin and not so heavy as to hinder their movements.

When net is used, the proper size of mesh should be selected for the age of the worms, as has already been indicated before, and it is hardly necessary to say that it should be clean and dry.

CHAPTER VIII.

Spacing.

NECESSITY OF SPACING.

THE development of silk-worms differs greatly, no doubt, according to the variety, the season and method of rearing; but whatever the variety, or season, or method of rearing, the growth, relatively to the size of the newly brushed worms, is really most remarkable. Generally speaking, the development is :—

In the 1st age	... 14 to 15 times the weight at brushing.
Do 2nd age	... 55 to 65 do
Do 3rd age	... 280 to 350 do
Do 4th age	... 1,300 to 2,000 do
Do 5th age	... 6,000 to 10,000 do

The size of the silk-worm also increases, though not in exact proportion to the weight. This increase is as below :—

1st age	... 10 to 12 times the size of the newly brushed worms.
2nd age	... 50 to 60 do
3rd age	... 250 to 300 do
4th age	... 1,400 to 1,600 do
5th age	... 6,000 to 7,000 do

The increase in mere length is as below :—

End of 1st age	... 2½ times the length of the newly hatched worms.
Do 2nd age	... 4 to 5 do
Do 3rd age	... 7 to 10 do
Do 4th age	... 13 to 15 do
Do 5th age	... 23 to 27 do

The increase in the breadth in thickness is as below:—

End of 1st age	...	more than 2 times the breadth of the newly hatched worms.
Do 2nd age	...	nearly 4 do
Do 3rd age	...	6 to 7 do
Do 4th age	...	10 to 13 do
Do 5th age	...	17 to 22 do

The above figures will give some idea of the marvellous nature of the development; but in spacing, the factors practically to be considered are the increase in length and breadth, as these furnish data for calculating the area actually covered by the worms as they grow. If we know the actual space occupied by a single worm at a particular age, we can calculate the actual space of bed which a given number of worms require at a particular age. The above considerations will enable the practical rearer to make his own calculation wisely, after seeing the growth of his worms and to gradually give more and more spacing as the rearing progresses. It would be misleading to give any fixed figures, as the actual size of the worm at a particular age differs greatly according to the variety and the season of the year when it is reared. Regard must also be had to the fact that in the earlier stages particularly, a large number of worms are lost in cleaning, etc., and that there are never the same number of worms at the end of the rearing as there were at its commencement.

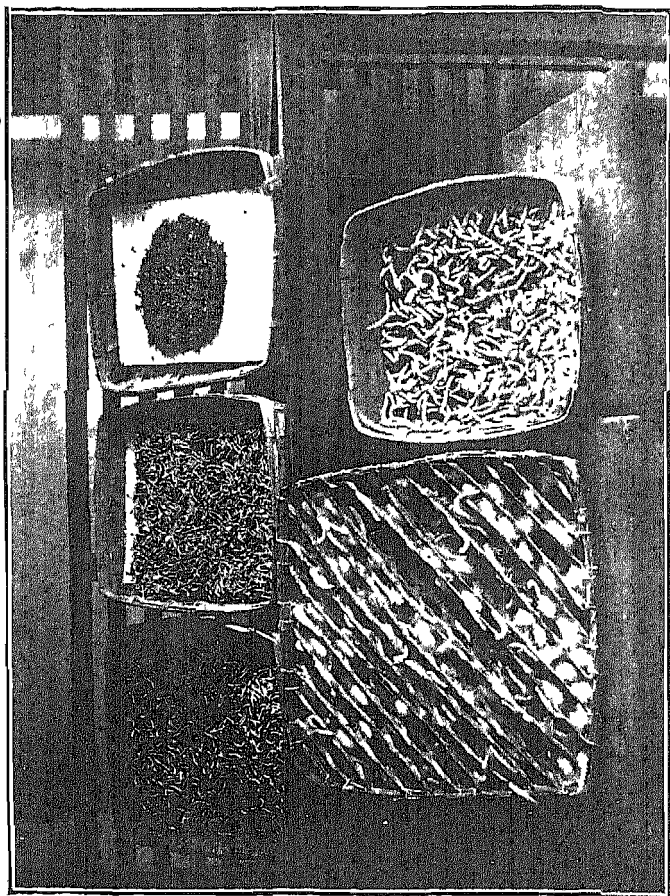
When we say that the actual space covered by a single worm is an indication of the space required for a rearing with a given number of worms, we must not be taken to mean that the space to be given should be just a multiple of the individual requirement into the number of worms. We must remember that the worms have life, and have to perform vital functions. We know that they breathe, move about in search of food, eat, rest, and have their entire being in the silk-worm bed, which to them is

their world. It will not do to pack them together as close as they can be packed in one layer, so that they are laid side to side and end to end on the bed, and yet this is what many a raiyat does in his rearing. These little beings are so crowded together that they quite cover the entire bed and are sometimes crawling over one another in a desperate effort to secure some space for movement. They have to get such air as they can, and they have to eat such food as they get, contaminated as it is with the droppings and excreta of other miserable worms. And all this time they have the love of life strong in them and they are growing rapidly. If space were lacking, it would be far better to throw away some of the worms than rear them all in a confined space.

The spacing should be regulated according to the age of the worms. In the earlier ages, the development is quicker, and therefore the increase of space should be greater in proportion. The following table, which has been worked out as the result of experience, may be found useful:—

Age		Size of bed		
1st	...	3 to 5 times the space actually covered by the worms.		
2nd	...	2½ to 4	do	do
3rd	...	2 to 3	do	do
4th	...	1½ to 2½	do	do
5th	...	1¼ to 2	do	do

It will be noticed that in the above table instead of a specific figure, we have given certain limits, such as, 3 times to 5 times. These limits denote the range of what is proper and may be adopted. Some specialists think that 3 times would do till the next spacing; others, that 5 times would be better, having regard to the fact that the worms are growing all the time. It should be understood that



WORMS OF VARIOUS AGES

(From top right to left) 1st age, 2nd age, 3rd age, 4th age,
ripe 5th age worms, mounted

anything less than 3 times would be too little and anything more than 5, wasteful.

The above directions are of general application and may be safely adopted everywhere, due regard being had to local conditions and the nature of the worms reared. For the practical guidance of rearers in Mysore specially, we give below a schedule of spacing, calculated for a crop of 100 layings of the Mysore race of silk-worms on the basis of repeated and careful experiments. Two tables are given—one for the period of the year when the worms attain their greatest size, and another for the season when their development is least. These cases mark the extreme limits of conditions met with in Mysore sericulture; and all grades of other conditions which occur during the intermediate seasons will be found to lie between these limits. It has been ascertained that in Mysore, silk-worms attain their best development in the period from the beginning of August to the end of November. The period of least development is from the beginning of February to the end of April.

TABLE FOR SEASON OF GREATEST DEVELOPMENT.

Quantity Brushed—100 Layings.

1st age	... $2\frac{1}{2}$ sq. ft.	... Beginning
	$12\frac{1}{2}$ sq. ft.	... End of 1st age
2nd age	... $12\frac{1}{2}$ sq. ft.	... Beginning
	25 sq. ft.	... End of 2nd age
3rd age	... 25 sq. ft.	... Beginning
	50 sq. ft.	... End of 3rd age
4th age	... 50 sq. ft.	... Beginning
	125 sq. ft.	... End of 4th age
5th age	... 125 sq. ft.	... Beginning
	250 sq. ft.	... End of 5th age

TABLE FOR SEASON OF LEAST DEVELOPMENT.

Quantity Brushed—100 Layings.

1st age	... $1\frac{1}{2}$ sq. ft.	... Commencement
	$7\frac{1}{2}$ sq. ft.	... Close

2nd age	... 7½ sq. ft.	... Commencement
	15 sq. ft.	... Close
3rd age	... 15 sq. ft.	... Commencement
	30 sq. ft.	... Close
4th age	... 30 sq. ft.	... Commencement
	75 sq. ft.	... Close
5th age	... 75 sq. ft.	... Commencement
	150 sq. ft.	... Close

A few words of explanation may not be out of place. In the 1st age, the space allowed is greatly in excess of the actual area covered by the body of worms. This proportion is gradually decreased as the rearing progresses; and the result is that, while the worms appear very thinly distributed in the bed in the earlier ages, they look comparatively closer to one another in the later stages. There are reasons for this arrangement. In the earlier stages, the space covered by the worms is small and their development is very rapid. The space given to the bed has an intimate connection with the quantity of the leaves required for feeding, as enough must be sprinkled to cover the bed. As the absolute quantity of leaves required at this stage is small, a generous allowance of space for the growth of the worms does not entail any appreciable increase in cost of leaves. In the earlier stages of the rearing, the number of worms undergoes diminution through loss of a few worms in change of beds, etc., and this loss cannot be avoided with all practicable care. In a normally good rearing, only about 75 per cent of the worms brushed actually arrive at maturity. The worms do not develop relatively so fast in the later stages; and also as the quantity of food required increases the need to avoid waste of leaf also becomes a very important consideration. In the earlier ages, the individual worms cannot be so clearly distinguished by the eye as in the later stages and for this reason, a good many are lost. Of the total loss of 25 per cent throughout the rearing, quite 10 per cent are lost in the 1st age alone. For this reason, it is safer to give a liberal allowance of space.



SILK-WORMS IN THE 5TH AGE (AFTER PASSING 4TH MOULT)

TIME AND FREQUENCY OF SPACING.

As spacing is intended to provide room for the worms as they grow, it follows that theoretically, spacing ought to go on simultaneously with the continuous development of the worms; and that, at least, it should be given each time there is a feeding. But in practice this is quite impossible, and therefore the method adopted is to give spacing at convenient intervals, allowing at each spacing enough room to provide for the development which takes place till the time comes for the next spacing.

In the 1st age, the development of the worms is most rapid, and therefore the spacing has to be most frequent. The first spacing should be given on the day after the worms are brushed, and thenceforward, spacing should be done every day, till the day when the worms show signs of going into moult. By the end of the 1st age, the space given should be of the limits indicated in the table. On the day when there is cleaning also, the spacing can be advantageously taken up at the same time, as it would save labour and would also be more uniform. Otherwise, the spacing will have to be done independently, and will require careful attention to secure evenness of distribution, by picking out worms where they are thickest, and putting them in places where there is room.

From the 2nd to the 4th ages, the first spacing in each age should be given several feedings after the worms have come out of moult—preferably at the time of the first cleaning. The next spacing should be given some time before the middle of the age, when they begin to feed vigorously. The third spacing should be given just before the period of greatest appetite. There should thus be three spacings in each age, and the best way to conduct them would be to combine them with cleaning. At the end of each age the worms should have the space specified for that age in the table.

In the 5th age, the first spacing should be given, as in the previous ages, several feedings after the worms come out of moult. The second spacing should be given just before the middle of the age, when the worms show an appreciable increase of appetite. Two spacings will do in this age.

As has been said before, spacing can be done at any time; but it would be best to do it at the same time as the cleaning, both from the point of saving labour, and to secure uniformity. When, owing to the accumulation of litter, or for any other reason, it is found necessary to clean the bed, spacing may be attended to at the same time.

METHOD OF SPACING.

As indicated in the foregoing paragraphs, there are two methods of spacing, either conducting it independently or in combination with cleaning. In the former case, where the object is just to spread out the worms over a more extended bed, a convenient way is to mark out on the tray the limits of the increased space desired, and to distribute worms on it by picking out worms from the parts of the bed where they are thickest, so that, in the end, they are evenly distributed over the whole of the increased space. Where spacing is combined with cleaning by husk and net, the worms are taken as a whole from the old bed, and distributed evenly over a new bed of the required space. This is most convenient and satisfactory. When cleaning by net alone is done, the process becomes slightly more complicate, as it will be similar to independent spacing.

It will be noticed that in the course of a rearing, between spacing and spacing, the area covered by the worms will gradually expand of itself as the feedings go on. This is quite as it should be, and is all the better for the worms. It may also happen that in the intervals between the times fixed for spacing,

the development of the worms has been hastened by conditions of food or temperature, and they appear crowded. In such a case, the rearer should, without hesitation, give more space at once, even though the appointed time has not yet come.

CHAPTER IX.

Special Treatment Required During Different Periods.

THE period in which the silk-worm is at a particular time can best be known by characteristic outward marks. It is important to know this, as the treatment to be given has to be adapted to the particular period.

FIRST PERIOD.

This is the period when the worms have just hatched out (if in the 1st age) or just come out of moult (in the subsequent ages).

Worms which have just hatched are, in general appearance, short and thick; the head and fore part are comparatively much thicker than the rest of the body. The middle portion is slightly constricted. The worms are dark or darkish brown, and are covered with hair.

In the appearance of worms which have just come out of a moult, there is some slight difference according to the age in which they are; but they have the following common features, *viz.*, that they are rusty to begin with, that after some time they appear spotted with white patches, and that the skin is loose and folded. They have also no lustre. The hinder portion of the body is comparatively broad, and the hindermost legs seem to be turning outwards. The worms are in the habit of raising up their heads, and the heads appear to be comparatively big.

The most essential thing in this period is to determine the proper time to feed, and the proper quality and quantity of food to be given.

In the chapter on brushing, we have already said that the best time to feed worms just hatched is before noon, by when most of the worms will have hatched, and that very tender leaves should be finely and evenly chopped and given for food.

The best time to feed worms in the other ages is several hours after they have come out of moult, and when they begin to move restlessly. Immediately after coming from moult, their bodies are moist and their appetite very dull, and though some might attempt to consume food, it might injure them. Though in a properly conducted rearing, the development of worms ought to be uniform, and the greatest part of the worms ought to go into and come out of moults at the same time, yet it often happens that, in the first period, difficulty is experienced through some of the worms coming out of moult, while some are still in moult.

If a feeding is given in these circumstances, the worms which have come out of moult will begin to eat, and their development will quickly outstrip that of the others, and the lack of uniformity will thereby be increased very greatly. If they are not fed, there is another difficulty. It may be that they have come out of moult several hours before, and are very hungry. If they are kept unfed, to await the other worms, they may get extremely weak, especially when the air is hot and dry.

The following simple rules furnish a common-sense solution of this difficulty:—

If the worms still remaining in moult are a very small part, and the great majority have already come out, and are showing signs of hunger, neglect the few late worms, and feed the rest.

If the great majority of worms are still in moult, but a few have already come out of moult, and might be fed, wait till the others have come out of moult.

If the number which have come out of moult

and those which still remain in moult are both so large that you cannot afford to neglect either, then separate the ones which have come out, from those *which are still in moult, by using a net and giving a feeding*. In this case, the late worms after they come out of moult should be given special treatment, such as better leaves and more frequent feedings, and kept on the upper shelves where the air is usually warmer, to enable them to regain lost ground, and become uniform with the other worms.

The above instructions indicate the collective treatment of worms in a tray; but a knowledge of the appearance of individual worms, which shows when they ought to be fed, would be useful in arriving at a correct judgment. A worm, when it comes out of moult, is moist and dull in colour, and inactive. It is also flabby in appearance. A little time later, it becomes dry, looks stiff, and white patches appear upon it as though it had been sprinkled with white powder. Then the colour becomes deeper, and the worm raises its head and begins to move about restlessly. This is an indication that it is hungry and wants food. In the selection of food, it must be remembered that this is the most delicate period, and that parts of the alimentary system have also been renewed and are tender, and therefore apt to be injured by coarse leaves. The mouth parts are likewise tender, and not suited for chewing tough leaves. Therefore the tenderest leaves, suited to the age, should be selected. Coarse leaves would derange the digestive system and initiate *flacherie*—a digestive disease to be described later.

As the worms have fasted long, they have a vigorous appetite and therefore the feeding, though tender, should be ample; otherwise, only the more vigorous worms would get enough food and the others would suffer. At this stage, the worms are very sensitive to rough handling, or draughts of air, or strong light, and they are more liable than at other

times to diseases which are communicated through the skin; so, special care should be taken to avoid these causes of injury. After a few feedings, when the worms are grown stronger, a cleaning should be given.

SECOND PERIOD.

In the 1st age, the second period may be said to commence after about 4 or 5 feedings, and to be complete when the hairy appearance of the worm has disappeared.

In the other ages, it commences after the first cleaning. The worm is then thin and long and dark in colour; the head appears proportionately small for the body. Gradually the worm turns to a bluish colour, as the folds in the body begin to stretch. In this period the appetite decreases; and, in fact, this is the period of least appetite. The worms are still delicate in condition, and require care in selecting the right quality of food, and protection from draughts of air and other disturbing factors. The leaves should still be soft, though not so soft as in the first period; but the quantity can be curtailed. In this period, the worms prefer and require a dry bed, and superabundant feeding would lead to a thick damp bed. The temperature should also be slightly higher than at other times. The second period generally extends from half to one day but differs slightly in different ages.

THIRD PERIOD.

After the end of the second period, the blueness of the body becomes more pronounced. The worm looks fuller, and the skin begins to shine. Then, whiteness appears in parts of the worm. The worm has a greatly increased appetite. This is the longest period, and is generally 1 to 2 days in duration in the first four ages; and about 3 days in the 5th age. The worms also appear long in proportion to their

thickness in this period. During this and the previous periods, the growth of the worm will be linear more than lateral, and the skin is being stretched. The blueness is due to the colour of the contents of the alimentary canal showing through the translucent stretched skin. The accumulation of leaf in the alimentary canal is itself more than in other periods. The whiteness which appears later is due to the deposit of fat next to the skin. The quality of leaves to be fed during this period should be comparatively mature considering the age, and the quantity should be sufficiently ample to satisfy the appetite of the worm which is rather keen in this period. The temperature should also be comparatively high considering the age, but should be slightly lower than in the previous period. The humidity should be comparatively low and spacing should be liberal, as in this period, the growth is comparatively large. Cleaning should not be neglected, as there is a rapid accumulation of litter.

FOURTH PERIOD.

In this period, the development of the worm is mostly in thickness, and the whiteness gradually increases. This period generally lasts 1 to 2 days. The change in size and appearance is mostly due to deposit of fat. This is the period of greatest appetite. The fat is deposited as a preparation to go into moult when the worms do not eat, and have therefore to use up their store of fat. The worms in this period require a good quantity of food—in fact, the most essential requirement is as much food as they can eat. The worms in this period are not delicate at all, but quite robust and vigorous. The temperature should be kept comparatively low. If the temperature is high, this period will pass quickly, before the worms have had time to take full advantage of their robustness and appetite to attain full development. A low

temperature, by protracting this period, ensures a fuller growth. The humidity should be slightly lower than at other periods. The ventilation requires special attention, and should be quite free and ample. Unless there is risk of strong winds, or danger from exposure to direct sunlight, all doors and windows should be kept open. Spacing should be sufficient and the bed should be kept free from litter.

FIFTH PERIOD.

This is the pre-moulting period. After having eaten vigorously, the worm now appears quite fat and plump especially in the head and portion next to it (from 1st to 3rd segment); by comparison with its thickness, it gives an impression of shortness, and the hinder segments appear thin. The body is quite shiny and inclines to an amber colour, this change of colour being due to the formation of light brown new skin underneath the tightly stretched old skin. The front part of the worm appears to be swollen owing to the formation of the new head. The worm likes to rest and to raise the front portion of its body. The appetite of the worm is very low. This is a sign that the worm is preparing to go to moult. This period is generally less than half a day. The most important treatment required in this period is change of bed. We must look in the bed for early moulting worms, and if we find them, we must immediately prepare for cleaning. In this period, they prefer a dry bed, and if the bed is at all damp, they hesitate to go to moult, *i.e., moulting is delayed by a moist bed.* Also, if cleaning is neglected in this period, so large a proportion of the worms go into moult, that cleaning is rendered impossible till all the worms have come out of moult; and the thick uncleared bed will be a very favourable field for the development of disease germs. Worms, which have just emerged from moult, have very little resistant power and easily fall

victims to disease germs. It is important not to miss the right time for cleaning in this stage. If the cleaning is too early, the bed again gets thick with accumulated litter; if cleaning is delayed, there will be so many worms already in moult that it becomes impossible. So, the best time to clean is when the first few early worms are found to be in moult, as already stated. When the development of worms is unequal, it would be better to do the cleaning rather later, though it entail sacrifice of a number of early worms; otherwise, there will have to be so many feedings afterwards till all the worms go to moult, that the bed becomes quite thick. When the climate is cool and damp, the same treatment is necessary to avoid accumulation as it will take long for the worms to go into moult. On the contrary, when the development of the worms is very uniform, and the temperature is warm and dry, cleaning should be done very promptly, or it will become impossible, owing to most of the worms going into moult almost simultaneously. After cleaning, the subsequent feedings should be greatly reduced and made thin to avoid accumulation of leaves. The size of the chopped leaves should be smaller and their shape narrow to avoid dampness. Finally, when the majority of worms have gone into moult, and only a few unmoulted worms remain here and there, feeding must be sprinkled very thinly only where it is required. If, even after this, a few worms are still moving, it is better to pick out these worms (as they are obviously very weak and probably diseased) and stop feeding. Feeding must be stopped at such a time that the leaves have become quite dry before the earliest worm has come out of moult. If, owing to damp conditions, a large number of worms remain without going to moult, they must be separated out by feeding over a net. Such worms should be given special treatment, such as, tender leaves and a warmer place, to hasten their development and bring them into line with the other worms.

In this period, the temperature should be kept comparatively high, and there must be free ventilation to keep humidity low, and these conditions hasten the worms going into moult. It is a bad thing if it should happen to rain when the worms are in this period, as the worms will hesitate to go into moult, and litter will accumulate. In this case raising the temperature, and free ventilation become absolutely necessary. If the bed accumulates in spite of all precautions, it may be found advantageous to re-arrange the surface into alternate ridges and valleys to secure better aeration.

SIXTH PERIOD—MOULTING PERIOD.

The five periods described above may be called pre-moulting periods. At the end of them, the worm goes into moult. The colour of the worm, which was amber, becomes darker; the worm spits out silk and fastens itself by its head part to some dry leaves or other substance, while it rears its head and forepart and remains immovable. It dislikes disturbance of any sort, and is greatly agitated by a draught of air, or a touch, or a jar of any kind. The front portion of the body appears smaller. Immediately behind the head, there are spots of dark brown colour, which become more pronounced, bigger and darker as the period advances. Worms which are quite healthy raise up their heads in a more pronounced fashion than weakly ones, so that the uniformly upright position of the worms in a tray is a very good indication of the health of the worms. This position is characteristic of the beginning of the moulting period. Towards the end, the head and fore part are gradually lowered, and finally the worm begins to stretch its body, in an effort to break the old skin at the head. At that stage, the head of the old skin appears almost as though it is hanging, while the new head appears like a brown spot on the top. The worm then

commences to move its body in an undulatory way, and finally the old skin breaks at the head, and the new head comes out of the breach. This occurs when the renewed worm has succeeded in moving itself to the length of one segment out of its old skin. This can be clearly seen in marked worms; also, as the undulatory movements progress, the *trachaea* which are pulled out of the spiracles give the effect of a dark line on the sides of the worm. After the worm has come partly out, it plants its thoracic legs and with their help gradually, and with great effort, wriggles free of the old skin. Properly speaking, the moulting period commences when the worms change colour and raise themselves up, and terminates when they get entirely free from their old skin; but, in practice, that term is used to denote the entire time comprised between the stopping of feeding when the majority of worms are in moult and the recommencement of feeding some time after the majority of them have come out of moult.

It might, at first sight, appear as though this is a period of absolute rest for the worm, as it outwardly appears asleep and does nothing; but really, it is a time of great internal activity. A new skin and a new head have to be formed inside the old ones; the other parts renewed are the membrane lining the front and hind portions of the alimentary canal, the *trachaea* and the chitinous membrane which lines the front portion of the silk glands. All this has to be done, and the vital functions have to be fulfilled. The work thus done is indicated by the using up of the amount of fat which had been stored up in the pre-moulting period. Moulting is necessary for the further development of the worm; for, the skin which is a chitinous membrane does not grow, but can only be stretched to a limited extent, and as the inner organs continue growing, this limit is soon reached and the skin which can stretch no more has to be broken to permit of further development. As during

this period all the energy of the worm is required for these important internal changes, its resistant power to external circumstances is very small; and this is therefore a period when it is most susceptible to disease. When it has just cast off its skin, it is in its most delicate condition, as it is quite fatigued, and has no other protection than a soft tender skin. During this period, it is necessary to maintain a uniform temperature and humidity, and exclude all such disturbing influences as draughts of air, or strong sunshine. The room should be kept still and quiet. In the very beginning of this period, the temperature should be kept comparatively high, and the humidity, comparatively low, and this should be maintained throughout. This ensures the normal progress of the function. A low temperature and high humidity would make the function dull, and the worms would remain longer in moult. If, on the other hand, the temperature is extremely high and the humidity correspondingly low, the worms would be too greatly debilitated. Towards the close of this period, that is to say, when the earliest worms are found to have come out of their old skins, the temperature should be lowered a little and the humidity slightly increased. A slight increase of humidity will facilitate the removal of the old skin. In fact, to enable the worm to crawl out of its old skin, nature provides a layer of mucous fluid, which would dry up if the air was too dry; and a slight degree of humidity in the air aids in its conservation. A slight lowering of the temperature will also help to keep the worms from too rapid exhaustion in the time they have to wait till their first feeding is administered to them.

CHAPTER X.

Particular Treatment During Each Age.

FIRST AGE.

THE success of a rearing depends, in great measure, upon the care and skill bestowed in the earlier ages. If the worms have been spoiled by carelessness or ignorance in the earlier ages, no amount of subsequent trouble will ensure a complete success. On the other hand, worms which have received a sound basis of good health by proper treatment in these ages, are comparatively well able to resist adverse circumstances later in the rearing. By earlier ages, we mean the first two ages. In these ages, the worms are very delicate and very susceptible to ill-treatment. They are, moreover, so tiny that individuals do not appeal to the sympathy born of distinct sight and touch, and the rearing consists of mass treatment. The tiny worms are also more liable to be lost than more grown ones—indeed a good many are, as a matter of fact, lost in spite of normal care and skill. About half of the total loss of worms occurs during the 1st age.

Quality of leaves.—The 1st age worms require the tenderest leaves, chopped very finely, and separated from stalk portions. Coarse leaves are, in this age, difficult of digestion, and growth would suffer in consequence. Fine chopping would facilitate the feeding of the worms, and also enable economy in feeding.

Feeding.—The quantity of feeding at a time need not be much, but the frequency of feeding should be so regulated that fresh food is given before the leaves of the previous feeding are entirely dried up, so that there is always food in a fresh condition for the

worms. In this age, the development of the worms is most remarkable, being from 10 to 15 times their original weight; and it is essential that they should have food to build up their body.

Spacing.—Spacing should be sufficient for this great development.

Cleaning.—Cleaning should not be attempted in the beginning as the worms are so delicate as to be liable to get injured, and so tiny as to be in danger of being lost. After two days, when the hairy appearance has disappeared, cleaning may be given for the first time. One more cleaning should be given just when the worms show signs of going to moult.

Temperature and humidity.—In this period, the temperature should be rather high: for polivoltines and bivoltines, 75° to 80° F, for univoltines, 70° to 75° F. The humidity, in the case of all kinds, should be from 60 to 75 per cent. There is no need of very free ventilation, and currents of air make it difficult to control temperature and humidity. They also make the feeding dry up quickly. The aim should be to keep the air in the room still, so that temperature and humidity may remain steady.

SECOND AGE.

The main characteristic of this age is that it is very short. Though the absolute increase in size is not great, the rate of development is rapid. The result is that the rearer will have to be very prompt with every operation; for if he miss any, there will be no time to rectify the omission.

Feeding.—The number of feedings should be as in the previous age, but the quality of the leaves need not be quite so tender, but must not be coarse by any means. The size of chopping should be slightly bigger to suit the increased growth.

Spacing.—Spacing should be sufficient, as the growth is rapid.

Cleaning.—Three cleanings should be given as detailed in the chapter on cleaning.

Temperature and humidity.—Similar to what has been specified in regard to the previous age. The worms are still delicate and require care in handling, and protection from sudden changes of temperature and humidity.

THIRD AGE.

At the beginning of this age, worms will be 70 to 80 times their original weight when they just hatched out, and by the end of this age, they will have developed to 300 to 400 times that weight. As the worms are fairly developed by now, their treatment becomes comparatively easy. In this age also, the external characteristics of the variety which could not be distinguished in the earlier ages, such as, marks and cloudiness, stripes, etc., begin to appear. Their resisting power is increased by feeding. The appetite of the worms becomes very marked, indicating a need to increase the quantity to be fed at each time. The frequency of the feeding may be decreased by one time, as the leaves, being more mature and chopped into larger sizes, are slower in drying.

Cleaning and spacing.—Four cleanings should be given as detailed in the chapter on cleaning, and spacing should be adapted to the growth of the worms as indicated in the chapter on spacing.

Temperature and humidity.—Same as in the previous age. More attention should be paid to ventilation.

FOURTH AGE.

At the beginning of this age, the worms are, as we have seen, about 300 to 400 times their weight when newly hatched. During this age they grow to be about 1,500 to 2,000 times that weight, or, in other words, they develop to about 5 times their weight in this age. As they are already big, their growth is very

appreciable, and a larger number of trays is necessary. This age makes a very marked transition in the nature of rearing; for, whereas skill and care were the most important factors in the earlier ages, labour and cost of labour now take the first place.

Feeding.—The appetite of the worms has greatly increased, and they require 3 to 4 times the food they consumed in the previous age. A large quantity of slightly more mature leaves than indicated for the previous age has to be fed; but the number of feedings may remain the same.

Cleaning.—Same as in previous age.

Temperature and humidity.—The temperature should, on the average, be about one degree lower. The humidity may remain as before. In this age, special care should be given to ventilation, as insufficient air tends to make the bed damp and facilitates the outbreak of diseases. From this age, the litter becomes a marked feature of the bed and points to the necessity for cleanliness.

FIFTH AGE.

This is the longest age, especially in the Mysore race of worms. This is the last age, and at the end of this age, the worm will have reached its maximum weight of 6,000 to 10,000 times its weight when just hatched. The quantity of food consumed in this age is very great, amounting to three-fourths of the total quantity to be fed throughout the entire rearing. The necessity for all this food becomes apparent when it is considered that not only has the worm to develop silk glands and secrete silk, but has also to store up nutriment and energy for the coming series of metamorphoses from the larval to the pupal condition and finally to imago or moth. This age is therefore no less important in the life history of the worm than it is to its industrial value. It must therefore have as much food as it requires. It would be false economy

to save leaves. Care should likewise be taken to see that the quality of leaves is also good. They must be the most mature leaves and must also contain plenty of nourishment. As the worms eat very voraciously, a large quantity can be fed at one time, and as in this age the leaves are so mature that they do not dry up quickly, the number of feedings may be decreased.

Cleaning.—Owing to the large quantity of leaves fed, and the great mass of excreta which worms are continually passing, the bed rapidly becomes thick, damp, and evil smelling. As the worms advance in age, the excreta also become more damp and sticky. It is therefore very important to clean the beds as frequently as possible, and as the worms are quite big by now there is no danger of their getting lost.

Spacing.—Spacing should be done twice about the middle of this age.

Temperature and humidity.—The temperature should be about 4° lower than in the first two ages, so as to prolong the period, and make the worms eat more and secrete more silk. Humidity may be the same as in the previous age, but as the worms approach their greatest appetite period, there must be freer ventilation. In this age, ventilation should be specially attended to, as insufficient ventilation is a fertile source of disease. The exhalations from the damp and rapidly accumulating litter, added to the respiration of silk-worms and rearers, make the air heavy and impure very quickly, and so, it is important to have as free a passage of air as possible. At the end of this age, after the worms have eaten enough, their appetite becomes sluggish, and they shrink in length, and appear round in shape. They also turn slightly yellowish. The solid excretions become soft and finally, sticky. At this stage, the colour of the excreta becomes faint and greenish and this is a sign that the worms are ripening, and that it is necessary to arrange for mounting them.

CHAPTER XI.

Mounting and Harvesting.

GOOD rearing is the only way to secure good cocoons, and it must be clearly understood that where this essential condition is wanting, no amount of care in mounting will enable the rearer to get a good harvest. But granted good rearing, good mounting will secure to the rearer the full fruit of his labour. Properly reared worms, when ripe, will try to spin good cocoons even under unsuitable conditions; but it must be remembered that the object of the worm in spinning the cocoon is to protect itself from hostile disturbance when preparing for the momentous changes it has to undergo, and not to help the rearer by yielding easily reelable cocoons of good lustre and commercial value. The rearer can get this reward for his labour only if he co-operates with the worm by making the conditions such that, by spinning a commercially good cocoon, it also most efficiently protects itself. This co-operation is good mounting. By bad mounting, it is possible to deprive oneself of the legitimate reward of good rearing.

RIPENING AND PICKING.

We have already described the appearance of a ripening worm. The colour becomes pale, slightly tinged with yellow; the body shrinks in length, and gets a round appearance; there is also a constriction at the 4th and 5th segments. The worm appears translucent at the constriction. It loses appetite and begins to look about as though in search of a suitable place to which to attach itself. It also commences to "spit out" silk. This is the time to pick it up for mounting. So much for the individual worm;

but it must be said that all the worms in a tray practically never get into this condition simultaneously, and it usually happens that, by the time the majority of worms in a tray are ripe, some of the early worms will be over-ripe. Over-ripe worms will have lost a quantity of silk by the time they are picked up, and they are moreover in such a hurry to spin their cocoons that they proceed to do it anyhow, without waiting to select a proper place, and thus produce irregular-shaped and flattened, or sticky cocoons causing loss to the rearer. If worms are allowed to get over-ripe before they are picked up, in some varieties, there is a very great increase in the number of double cocoons. On the other hand, if worms are mounted before they are fully ripe, they will move about, and sometimes fall off; and also they defæcate in the cocoonage, often soiling and lowering the value of the cocoons which other worms are spinning. The cocoons spun by worms which are mounted too early will be smaller and inferior. Therefore, the rearer should be careful to be ready with arrangements for the cocoonage when the worms are due to ripen, and he should pick up the worms as they ripen, and mount them without waiting for the whole tray to ripen. This necessitates more labour, but to stint work now would be to throw away the results of past work. He should therefore even employ paid help at this period, if necessary. The need for promptness becomes all the greater when the nature of the worms is to ripen quickly, or the progress of the worms has been uniform and the climate is warm and dry, as when the worms ripen in the middle of the day.

SPINNING.

The ripe worms, when they are picked up and placed in the cocoonage, first look about for a high and dry place in which to settle themselves, and having found one to their liking, they rest for a brief

space and excrete fæces and urine to prepare themselves for spinning. They then select a place for spinning. When worms are mounted in a *chandrike*, they are found to seek the top of the ridge; they do so to empty themselves of fæces and urine, and must not be disturbed. They would, if let alone, return to the proper place after this function is done. For spinning, they must have support on both sides at a proper distance apart. There the silk-worms stretch a filament from one side to another several times till it is sufficiently thick and strong. This they do in all directions afterwards, and thus prepare a kind of net hammock for themselves. This done, they lie on the hammock, and weave a similar layer on the top; the cocoon is then spun in the space between the two layers. They have commenced making their cocoons when they are seen moving their heads as though tracing the figure 8 all over the inside of the space enclosed between the two layers. They, in fact, spin thin layer after layer, each layer being composed of innumerable continuous figures of 8 finely laid in silk. After the cocoon is completed, they fasten themselves by a few last filaments to the inside walls, so as to help them in getting rid of the larval skin and also to keep them steady when in the pupal condition. When we understand the nature of these functions, we see how necessary it is to facilitate them by proper arrangements to protect the worms from external disturbance such as, strong sunshine, shaking, etc. It is specially necessary to provide good ventilation, as the worms have to get rid of a good deal of moisture in the process of spinning; the silk, though it is solid, is still wet, and needs to dry to set into a firm cocoon.

COCOONAGE.

By cocoonage is meant the arrangement by which it is sought to provide proper facilities to the ripe worm to spin a good cocoon.

The best cocoonage is therefore the arrangement which provides the most suitable facilities for the worm's work. The first essential is that the space must be of the proper size to enable the worm to stretch its first filament across. If the space is too large, the worm will have the difficult task of throwing its filament from one distant point to another, and naturally has to expend a large quantity of silk. If the distance is too great, it may be quite beyond the worm's power to span it at all, and it is obliged to seek out some other place, whether it is good or not, and poor cocoons—or in some varieties, double cocoons—are the result. In the opposite case of the space being too narrow, the worms are cramped in their operations, and the cocoons spun are smaller, irregular in shape, and uneven in thickness. This spoils their quality. The question is—What is the proper space to allow? The answer depends on the variety and the development of the worms. As a standard for general guidance, it may be said that the space should just allow of the free movement of the front half of the worm, that is to say, the part of the worm from the 5th or 6th segment to the head; supposing the worm is at the middle of the place, it must have room enough to move both sides freely. It must not be broader than necessary for this movement. For the Mysore worm, space of about an inch would do and bigger worms would require correspondingly more space.

The higher the cocoonage, the better it is. By height is meant the difference between the bed and the highest point of the cocoonage. In the *chandrike*, the height is the breadth of the tape which is fixed on the bed to provide space for spinning. The mature worm by nature prefers a high and dry place, and hates a low and damp place. The cocoon spun in a high place is of better quality than that spun at the bottom of the bed; because, the higher place is more airy and free from dampness, and contamina-

tion from silk-worm excreta. In the arrangement of the cocoonage, spaces in which the supports are arranged crosswise or in triangles are better as the silk-worm can adjust itself to a place which gives it just the most suitable interval for stretching its filament. The more acute the angle at which the supports cross each other, or make with each other, the more convenient it will be for the worms. In regard to the material for cocoonage, it should be flexible enough to be easily bent by the silk-worm in its efforts to adjust the space to its requirements; but it should not be so flimsy as to break down under the weight of the silk-worm. For instance, straw, while satisfying the condition of flexibility, is so flimsy that, where it is used, it is necessary to provide other supports to strengthen the cocoonage. The material should be of a nature which can absorb moisture and it should be dried before being used, as otherwise the cocoons would be stained and spoiled.

NUMBER OF WORMS TO BE MOUNTED IN A GIVEN SPACE.

However good the cocoonage, good results cannot be secured unless adequate space is given to the worms to spin cocoons. The earliest worms will, in a crowded cocoonage, get into the best places, and the other worms—especially the latest ones—will have to spin cocoons in such places as are available, and sometimes even on the cocoons spun by other worms. We are familiar in Mysore with long chains of cocoons which stick to one another as they are taken out of the *chandrike*, presenting no doubt a picturesque appearance, but really denoting a sad waste of silk. In some varieties, worms crowded together spin double cocoons. This is by no means the worst result of over-crowding. The worms soil and stain the cocoons of other worms with their excreta, and as in a crowded cocoonage, deficiency

of ventilation will hinder rapid drying of the moisture, damp, stained and inferior cocoons will be the result.

Too much space, on the other hand, certainly avoids all the above defects, and ensures good cocoons, but entails waste of space and labour, and should be avoided from the point of view of economy. Therefore, in practice, we should so regulate the space that, while giving the worms all the room they want for spinning good cocoons, there is also no waste of room or resources.

What, then, is the right amount of space which combines convenience to the worms with economy to the rearer? The right amount depends on the nature of the material and construction of the cocoonage, and also the race of worms reared and the season of rearing. In Mysore, with the Mysore race of worms, it has been found on experience that about 100 worms can be properly mounted on 1 sq. foot of cocoonage. In summer, when the development of the worms is less and the air drier, the number of worms may be slightly increased; in the cold season, when the opposite conditions prevail, it may, with advantage, be slightly decreased.

PROTECTION OF WORMS DURING COCOONAGE.

The worms require attention during cocoonage in the interests both of their health and of the quality of the cocoons they spin. Their health is specially important if the cocoons are intended for seed; and in all cases, the quality of the cocoons deserves consideration.

Temperature.—Generally worms, during the period they are spinning, require a slightly higher temperature than during rearing; but too high a temperature is to be avoided, as it will compel the worms to spin in haste—and haste, as we know, makes waste—in this case, silk waste. For, the worms

which are in too great a hurry to spin, waste a good deal of silk in the preliminary processes, and then make an irregularly-shaped cocoon which is of very poor reeling quality. This is specially the case with over-ripe worms, of which there are always a certain number. With some varieties of worms, the number of double cocoons is very greatly increased. Too low a temperature, on the other hand, causes delay in the spinning and injuriously affects the colour and lustre of the cocoons and their texture. The cocoon spun in a low temperature will not be so compact as that spun in a higher temperature. The delay occurs not only before the worms commence spinning, but the process of spinning itself takes longer.

The effect of too high a temperature on the filament is to make it thicker than the normal size, and of too low a temperature to make it thinner. If there is a fluctuation of temperature, it causes a corresponding variation in the function of spinning, and the result is that the different layers of the cocoon are not uniform, and do not stick to one another, and a flaccid cocoon is produced, which is a source of serious trouble in the cooking basin, and of great waste in reeling.

Abnormally high or low temperature affects the health of the worm and makes it unfit for grainage purposes.

It is therefore a matter of importance to determine the most suitable temperature during cocoonage. This differs with different varieties. A temperature of 80° to 85° F is found most suitable for the Mysore worm. For univoltine worms reared in Mysore, 75° to 80° F is a good temperature.

Humidity.—As is apparent from what has been said before, the silk-worm is so sensitive to temperature and humidity that it may almost be regarded as an indicator of the atmospheric conditions prevailing at the time. Humidity during cocoonage has an important bearing on the health of the worm and the quality of the cocoon. If the air is too damp,

worms which were only slightly affected during the rearing, either die in the cocoonage, or remain without spinning. The cocoons of the other worms become poorer, and the quantity of the output itself suffers diminution. Too much moisture in the air has a directly injurious effect on the quality of the cocoons by spoiling the lustre, and making them difficult to reel, entailing increased labour and decreased output. The silk reeled is also of inferior lustre.

From the point of reeling, the drier the air during the cocoonage, the better it is, but too great dryness debilitates the worms, and if the dryness is extreme, it may lessen the quantity of silk in the cocoon.

The proper degree of humidity is between 60 and 70 per cent.

Ventilation.—During the period of cocoonage, ventilation is an essential point for attention as a good deal of moisture has to be got rid of, and there is also a good deal of excreta—solid, liquid, and gaseous. Insufficient ventilation will spoil the health of the worms and the quality of the cocoons, and produce all the worst effects of dampness. The freer the ventilation, the better it is both for the worms and the cocoons, but by this it must not be understood that the cocoonage should be exposed to strong winds. A violent draught will prevent the worms from functioning properly. The habit of the Mysore rearer of placing the *chandrike* in the open air has much to recommend it, and is quite necessary to neutralise the effects of his other habit of crowding the worms in the cocoonage; but he must not place it out in a strong wind. He ought to select calm weather for placing the *chandrike* outside; if there is a strong wind, he should place it in the veranda, or under the protection of a tree or roof. It is not unusual to find the *chandrike* placed outside in such a way that strong direct sunlight falls on the worms.

This should not be done, as it causes all the bad effects of too high a temperature; and the worms hate direct sunlight as can be seen by the trouble they take to move out of it into the shadow. It would be better therefore to so place the *chandrike* that its back is to the sun, and the worms are on the shady side.

HARVESTING.

The worm will have completed spinning its cocoon in a day, and shortly afterwards, it begins to cast off its larval skin. This process takes about one day more. Immediately after casting off the larval skin, the pupa is of a very pale transparent yellow, and looks extremely soft and delicate. The body is very flabby. Then gradually with the lapse of time, the colour gets darker, and the body harder and stiffer, and this process continues till the pupal stage is complete.

Now we are in a position to judge which is the best time for harvesting. If we harvest too early, we take down the cocoons when the pupal skin is too soft, especially when the wings are folded, and the skin is apt to break at that portion at the slightest injury, and the blood of the pupa will stick to the inner side of the cocoon staining the cocoon a dirty brown or black as it dries. This explains the black and stained cocoons one sees so frequently in Channapatna and other places where the cocoons are harvested too early. This stain sometimes soaks through the whole of the cocoon wall, and whatever portion it stains becomes unreelable. In extreme cases of hurried harvesting, the worms will not even have completed spinning. In the stage when the pupation has just begun, the vital functions are most vigorous, and the pupæ are very apt to start fermenting during transportation of cocoons, with disastrous effects on the quality of the cocoons and the silk.

If the harvesting is too late, the most obvious

disadvantages are the delay in getting the return, and the loss caused by continued reduction in weight of the cocoons. Another inconvenience is that the period available for transportation and stifling becomes greatly curtailed, and there is a risk of moths emerging before the purchaser can stifle the cocoons. Where there is the fly pest, delay in harvesting would give the fly an opportunity of boring into the cocoon. In Mysore, luckily, this pest is non-existent. Late harvesting places the reeler who buys the cocoons at a disadvantage, by leaving him very little time for his treatment of cocoons.

The best time to harvest is when the pupa begins to turn brown, and its body to become firmer and less liable to be injured by handling. This stage is reached in about six days after mounting when the temperature is 70° to 75° F. When the temperature is 75° to 80° F, this is reached in five days, and when it is 80° to 85° F, in four days, and at a higher temperature in three days.

If the cocoons are destined for seed, it would be preferable to wait till the pupæ are still darker, and begin to be active, and to shake their hindermost portion. This means that the harvesting will have to be delayed by one day more.

The harvesting is the best time for sorting cocoons according to quality, as in taking them out, good ones can easily be distinguished from bad ones. In any case, stained cocoons at least can be separated without much trouble. It would be good also to sort out particularly flimsy and irregular cocoons. Those cocoons which, though they look well, are still not as good as the best, may be treated as second class. In fact, the sorting should aim at putting together in one class all cocoons which require the same treatment in reeling. This, if done at the harvesting, requires almost no extra labour and the reeler by graduating his prices to the quality can get the best return he has a right to expect, while the reeler will be glad

to buy a dependable and uniform quality, and pay for it. The worst features of Mysore harvesting are that the cocoons are taken from the *chandrike* too soon, and that good and bad cocoons, including stained and irregular ones, are mixed together; and this not only spoils the quality of Mysore silk as a whole, but decreases the price which the reeler can pay to the rearer.

Sorting becomes absolutely necessary in case the cocoons are meant for seed. Mixing will result in disease germs sticking to the seed cocoons, so that moths when they come out get contaminated, and the contamination is taken on to the eggs and to the next generation. Flimsy cocoons are generally produced by the weaker worms, and should never be used for reproduction.

CHAPTER XII.

THIS book would not be complete without some information regarding silk-worm diseases, rearing room hygiene, and seed selection.

Seed production and silk-worm pathology are very special subjects requiring a knowledge of genetics and biology and some familiarity with the use of scientific instruments; and it is not proposed to complicate this book with a hurried exposition of the principles of breeding or the technique of the grainage. But though the rearer need not provide himself with the knowledge and equipment necessary for the seed specialist, or the sericultural expert, he should still know enough to realise the importance of what they are doing for him, and in places where their assistance cannot reach him, he must know enough also to do the best he can for himself by securing reasonably good seed, and taking common sense precautions against disease.

That good seed is essential for a good crop is so obvious that nobody in his senses would dispute it—the sericulturist, least of all, who loses on the average about 30 per cent of his crops from defects attributable to faulty seed. In sericulture, badness of seed may take several forms of which the most important may be said to be these: the seed though good for another climate or other conditions may be unsuitable for the climate and conditions of the place where it is reared; or it may be tainted with hereditary disease; or it may be so lacking in vitality that without inherent racial unfitness, and without specific disease, it yields at best a poor crop, and is susceptible to the smallest unfavourable variation in the conditions of rearing. The recent attempt of a foreign firm to introduce univoltines in Kollegal and Yelandur is an excellent

instance of the first sort of badness. The rearings failed in almost every case. The second kind of badness is so important that the successful effort to eliminate it has made seed production a specialised branch of sericulture. The third kind can be, and to a large extent is, understood and avoided by the natural sagacity of the village rearer.

The rearer, to select wisely, must know both what to seek and what to avoid. He must know the external characteristics of a good seed cocoon, and he must know also what precautions to take and what enquiries to pursue to see that these appearances do not cover the reality of disease. As disease has to be avoided not only in the seed, but also from contamination in the rearing room, the rearer should know to identify the more important diseases and to take steps both preventive and palliative, so far as they lie within his power.

SILK-WORM DISEASES.

The four most important diseases of the silk-worm are Pebrine, Flacherie, Grasserie, and Muscardine. It is probable that other so-called diseases are merely symptoms of the first two named above. In Mysore, muscardine is rarely met with and is usually a result of failure to keep the silk-worm bed dry under moist conditions. The other three are together responsible for the loss to the raiyat of about 30 per cent of his crop. In our experience more than a half of this loss was due to flacherie; pebrine came next in destructive importance; and grasserie, though occasionally met with, never prevailed in what Dr. Pringle Jameson calls an epidemic form.

Pebrine.

Pebrine is a disease caused by a minute parasite called the *Nosema Bombycis*. The parasite produces

bright oval spores, which are so characteristic that they are easily recognised under the microscope and thus furnish a means for the detection of the disease. When the infection—which almost invariably begins in the gut as a result of the silk-worm eating contaminated food—has reached a certain degree of intensity, the disease organisms spread to the reproductive organs and infect the eggs, and thus pebrine for all practical purposes becomes a heritable disease.

Pebrine can thus be broadly divided into “hereditary” and “contaminative.” Hereditary pebrine is the infection in the seed obtained from diseased mothers. The eggs are infected, and the young worms hatch out with the disease already in them. Contaminative pebrine is what is caused to an originally healthy worm by imbibing infected material.

The only way of preventing hereditary pebrine is to use disease-free seed—either cellular seed from government grainages, or industrial seed raised with a basis of cellular seed by a seed rearer recognised by government. If rearers apply to the Sericultural Department, they will be placed in touch with reliable seed rearers, or registered on the distribution list of the grainages.

About disease-free seed, and about seed selection in general, a brief and non-technical description will be given later in this chapter. It is enough here to say that disease-free seed guards against hereditary pebrine, *completely* if cellular seed is used, and *to a great extent* if industrial seed is used; but no seed however good can yield satisfactory results if the rearing is exposed to chances of infection. Infection is most frequently caused by eating contaminated food—the contamination being either from spore-laden faeces in the silk-worm bed, from infected rearing appliances such as trays and nets, from spore conveying dust, or even from the clothes and hands of persons who have handled infected material. The Mysore raiyat's practice of forbidding strangers to

enter his rearing room or handling his worms is based on sound commonsense. The danger from pebrine is geatest if the seed used has a taint of disease in previous generations; hence the importance of knowing the history of the stock from which the seed cocoons are got. If the seed is *very* good, *fair* results can usually be got, for one generation, even in an infected rearing room; but to use infected *trays* is to court disaster. In the conditions prevailing in village rearing rooms in Mysore, if good seed is employed, there is but little danger of the crop being lost. We give below a few hints which will enable the rearer to identify this disease when he has the misfortune to meet it.

Symptoms of Pebrine. (a) *In the eggs.*—Pebrined eggs are notably deficient in sticking power, and get easily detached from the paper on which they are laid. They are laid in lumps, one over another instead of side by side; a pebrinised laying usually includes unfertilised eggs and dead eggs. The hatchings even of the other eggs are irregular.

(b) *In the worms.*—The sick worm is thinner and less active than a healthy worm. Its appetite is feeble; when it rests, its head, instead of being held up, hangs down. It usually passes connected (stringy) fæces. A bed of silk-worms affected with pebrine is extremely irregular both in going into moult and coming out of it. The affected worm lacks lustre, and in and after the 4th stage, the colour gets rusty brown, and the skin gets wrinkled. If the infection is intense, irregular spots sometimes appear on the abdomen and sides—but this is a symptom rarely met with in Mysore.

(c) *In the pupa.*—The abdominal part swells, and gets unusually soft. The colour gets dark. The pupa's movements get dull. In the sides, especially where the wings are forming, black spots may appear. As a rule, the heavily pebrined worm does not spin a good cocoon but spits its silk about and wastes it;

and it would be safe to conclude that the pupæ inside flimsy or irregular cocoons is probably infected and unfit for seed.

(d) *In the moth*.—The scales rub off easily, leaving the body bare in patches. The scales on the abdominal side and on the hind parts get discoloured; the wings do not stretch fully. The belly swells, and the moth does not move freely. There are sometimes (rather infrequently in Mysore) black round spots on the body and wings.

These are symptoms that can be seen by the intelligent rearer; but sometimes they are not all present, and often they are not very marked, but require careful observation.

In regard to pebrine, as in regard to most other evils, prevention is better than cure, and the best preventive methods are good seed, good sanitation and good rearing. This book, if it has served its object, has already set forth the essentials of good rearing, and also dealt to some extent with good rearing room sanitation. About the selection of seed and about the disinfection of the rearing room and its equipment, we shall say a few words later on; we shall only say here that a rearing room in which a crop has been lost through pebrine, should not be used again without thorough disinfection with formaldehyde solution (2 per cent strength). In Mysore, the Department of Sericulture does the disinfection on application for a nominal charge. Where the rearing room is so situated that it cannot be effectively disinfected, the best course is not to use it for rearing for at least six months. The rearing appliances should be well washed and dried for at least six hours in strong sunlight.

After infection has already spread, nothing much can be done, except pick off unequal-sized and dead worms. The healthy worms must be carefully spaced, and their beds must be changed frequently. If possible fresh trays—either new or carefully disin-

fect—might be used. With proper care, it should be possible to save a part at least of the crop.

Flacherie.

Flacherie is hardly less destructive than pebrine in countries where worms are reared throughout the year on bush mulberry, and in Mysore, it probably causes at present more loss to the industry than pebrine. It may be broadly said that whereas pebrine is a disease due to bad seed, flacherie is one attributable to faulty rearing. In Mysore, a better organisation of the seed supply has greatly mitigated the loss from pebrine, but it is to be feared that flacherie will continue without material abatement till the raiyats have learnt and can afford to practise better rearing. This improvement must, in the nature of things, be more gradual.

What is flacherie? All that is certain is that it is a digestive trouble fatal to silk-worms, and that it is associated, either as cause or as effect with certain micro-organisms. Opinion is divided about its causation and also about its heritable character. The result of recent research seems to be that the bacteria found in the body of a silk-worm suffering from flacherie are just those which are usually found on mulberry leaves, and from eating which the healthy worm ordinarily takes no harm. When the worm sickens through other causes, such as mal-nutrition and unfavourable conditions of temperature and humidity, these bacteria multiply and accentuate the disease. The Japanese specialists, who have contributed most to the knowledge of this disease, are of opinion that flacherie is not due to any special bacteria, but that the real causes are high temperature, high humidity, and bad ventilation, dirty, coarse, wet, or fermented leaf; and insufficient spacing. Some Japanese specialists believe that though, as a rule, flacherie is not caused by bacteria,

a special organism which they call the "Sotto" (sudden death) bacillus is capable of producing a violent toxin which is rapidly fatal to silk-worms.

Symptoms of Flacherie.—The worm loses its appetite, and becomes sluggish in movement. It sometimes shakes the front part of its body as if in great distress. As the disease advances, the dorsal vessel (that is to say, the pulsating streak along the back) pulsates rapidly and irregularly. The worm gets soft, and sometimes vomits. When the worm dies, its body gets soft, and discoloured, and rots rapidly emitting an evil odour. The 4th and 5th segments are stretched a little. When the attack has not been severe enough to kill the worm in the earlier ages, it may build a cocoon and change to a pupa, but ordinarily the pupa dies inside the cocoon, rots, and flows into the substance of the cocoon discolouring it very badly. A few may even live to become moths and to lay eggs. These moths are quite inactive and are peculiarly soft in the body. Their wings either cannot be stretched, or else seem stretched abnormally and there is a notable lack of scales on the body. After laying eggs, the moths die as though exhausted with the effort—and many die before laying eggs.

The only way to prevent this disease is to see that the exciting causes do not exist. Absolute cleanliness, proper spacing, regulation of temperature and humidity as far as possible by good and ample ventilation are essential. Good leaves must be used, suited to the age of the worm, and these should be free from dust and moisture. Diseased worms should be picked out promptly; the beds should be frequently changed, and the litter should not be allowed to accumulate and get damp. In short, the only prevention and only remedy is good rearing, as described in the earlier chapters of this book.

Grasserie.

Grasserie is a kind of dropsy, which may appear in any stage of the rearing, but usually occurs just when the worms are due to ripen. It is a very well-marked and easily recognisable disease. The swelling which first appears at the first segment of the affected worm gradually extends over the whole of the body; the stretched skin begins to shine, and finally bursts in places; and fluid escapes out of the breaks. It sometimes happens that the swelling is most pronounced at the segments, giving the worm the appearance of being noded like a bamboo. If the disease occurs just before moulting—which is the period at which it is most likely to occur in the earlier stages—the worm does not go into moult, but crawls aimlessly about, exuding fluid, till it dies. A ripe worm attacked with grasserie may spit and waste its silk altogether, or it may just spin a flimsy cocoon, and die within it before becoming a pupa. Some may even survive till pupation. The fluid which exudes from a sick worm is generally of the same colour as the cocoon which that worm would have spun; that is to say, worms of races which yield white cocoons exude white fluid, while those yielding green or yellow cocoons exude a green or yellow fluid.

There is no doubt that grasserie is a disease connected with assimilation. If worms are carelessly reared—especially in regard to the quality of the leaves fed to them—they get this disease. When, after a period of drought, there is a spell of rain which makes the leaves in the mulberry garden tender and sappy, the rearer had better be on the look out for grasserie. If after the worms have come out of a moult, tender leaves are fed to them too long, and are followed by excessively mature leaves, there is the same danger. There is a great likelihood of grasserie when races of worms usually fed on leaves from trees are reared upon leaves from bushes.

In these cases, special care is necessary in the selection of leaves. Possibly, if raiyats had a reserve of mulberry trees, leaves from which could be used when sudden seasonal changes affected the balance of composition in the bush leaf, this disease might (so thought Mukerji) be prevented to some extent; but this is mere speculation. The only remedy is good rearing, and good hygiene.

Muscardine.

Muscardine is due to a fungus or mould which gets lodgment in the body of the silk-worm, and penetrates it in all directions with its network of blood-sucking filaments. The name of the organism which causes the disease is *Botrytis Bassiana*. A high humidity is specially favourable for the growth of this fungus, and the disease is said to be peculiarly dependent on the weather. In Mysore, muscardine is seldom met with, owing to the temperature-and-humidity combination being unfavourable to its occurrence. It has been noticed however on the Bababudan Hills in October, and at H.-Narasipur (Hassan District) about the same season, after a week or so of continuous rain. At H.-Narasipur, bad weather was assisted by inexperience on the part of the rearer who allowed the silk-worm beds to get thick and moist.

A silk-worm affected with this disease becomes sluggish, and then stiffens and dies. A light discolouration can be noticed near the spiracles which spreads up the sides. Shortly after death, the body gets extremely hard, and looks as though made of limestone. The appearance is so characteristic that once it is seen, there is no possibility of mistaking it. Worms attacked by this disease, when they are quite ripe, might spin a cocoon, though this is rare; but they die inside, and never become moths. The disease is very infectious and the causal organism so

tenacious of life, that it is matter for thankfulness we have not to reckon with it seriously in Mysore.

The best way to deal with the disease is to pick out affected worms; change the bed, and if possible, the tray, of the survivors; space them and keep them very thin, and endeavour by ample ventilation, and by keeping open baskets of quicklime in the room to lower the humidity. Disinfection with sulphur fumes and formaline spray are also recommended. In Mysore, at least in the *maidan* parts, there should be no muscardine in a rearing conducted with reasonable care.

DISINFECTION.

In the preceding chapters the need for cleanliness, space, and air has been emphasised on all appropriate occasions. The need for regulating temperature and humidity by ventilation, and by raising protective screens of trees, etc., has also been referred to oftener than once—and it is unnecessary to go over the same ground again. A few words must however be said about disinfection. When it is seen that the most dreaded silk-worm diseases are due to living organisms, it will be readily understood that the best prevention is to kill all disease germs by the use of suitable disinfectants. This is specially necessary when a crop has been lost through disease, and there are consequently disease germs everywhere in the rearing room,—on the walls and floor and roof, on the stands and trays and other appliances, in the very dust which pervades everything in particular seasons.

The best disinfectants are perchloride of mercury, formaldehyde, and calcium chloride. Copper sulphate, which was once believed very potent, has been found to be practically ineffective against pebrine infection. Perchloride of mercury, though of unrivalled efficacy as a disinfectant is extremely expensive and is besides a most deadly poison. As it

also corrodes all metallic objects it comes in contact with, it is not to be recommended for popular use. Calcium chloride, without being anything like as costly or dangerous as the other, has still the disadvantage of being corrosive. There is no doubt that formaldehyde is by far the best and most convenient disinfectant for general use. It is sold in 40 per cent solutions under the name of formaline, and is inexpensive enough to be within the means of the more well-to-do rearers.

A 2 per cent solution of formaline is strong enough for all purposes of disinfection. The solution had best be made with hot water, as high temperature makes the disinfecting gas come out more briskly. The room to be disinfected should be closed, and crevices stopped, as far as possible, by pasting paper. A small room requires about a bucketful of a 2 per cent solution.

Mere disinfection is of little use without thorough cleanliness. All parts of the room should be washed with clean water; all drains should be flushed out, and all appliances should not only be cleansed thoroughly but exposed for at least six hours to strong sunlight. Water, air, and sunlight are natural disinfectants which are within reach of all, and it would be unwise not to use them fully.

Sulphur fumes are also fairly effective, but they are not as penetrating as formaldehyde, and have not the same potency in action.

Trays, after being washed and sunned, should be coddunged and dried again before use. It should not be forgotten that an infected tray is infinitely more dangerous than an infected rearing room. The instructions issued by the Sericultural Department of Mysore in regard to the disinfection of rearing houses and appliances are given as Appendix II.

SEED.

When treating of pebrine, reference was made to "cellular" seed as "disease-free" seed. The rearer will naturally ask for an explanation of these terms. We shall try to explain without being too technical.

Cellular seed.—To eliminate disease which can be inherited and which can also spread by contamination, it is essential that the mother-moths should be kept separate from one another at the time of laying eggs, so that the eggs laid by one do not get mixed up with those laid by another. For manufacturing "cellular" seed, each mother-moth is kept in a separate "cellule" by herself, where she lays her eggs and remains till she is wanted for examination under the microscope. Different kinds of cellules are used in different countries; in Mysore, mother-moths are confined in tin rings arranged in lots of twenty on paper. Each moth lays her eggs in the space comprised in her ring and they stick on to the paper.

The selection for "cellular" seed is two-fold; the first part consists of external examination, and the second, of examination under the microscope. The first part comprises an enquiry into the history of the rearing which produced the seed cocoons, the scrutiny of the seed cocoons themselves on principles which will be described later on, and the selection of the moths which emerge for robustness, vigour, and other external characteristics. The second part consists of the segregation of mother-moths, and their examination under the microscope. For this purpose each mother-moth is thoroughly crushed in a little water, care being specially taken to grind down the gut, and the resulting fluid is taken on a slide and examined under a microscope, usually with a magnification of 600 diameters. If this examination discloses the presence of any micro-organisms of disease, the lot of eggs laid by that mother-moth are cut out from the paper and destroyed. When all diseased layings are

thus eliminated from an egg-sheet, what is left on it is absolutely disease-free—provided of course that the work has been properly done. This seed is called “cellular” seed, from the circumstance that the moths which laid the eggs were isolated in cellules. The technique of manufacture is very perfect in well-organised grainages, and the rules observed in the Government institutions are given in an appendix to this book and may be found interesting.

Industrial seed.—It is obvious that this method involves cost and trouble, but where the eggs are required for raising seed cocoons, both cost and trouble are very well worth while, because a single diseased laying would transmit disease to more than one subsequent generation, and sow it far and wide.

But where the seed is wanted only for producing reeling cocoons, and the object is but to get *one* abundant crop as *cheaply* as possible, cellular seed would be unnecessarily expensive, though of course skill and attention are still required in selection of seed and a test examination of a certain percentage of it is also necessary to ensure that outward appearances are not belied by inward disease. The original seed employed for raising industrial seed should be “cellular,” and great care should be exercised in rearing. Seed thus produced and tested and intended only for rearing one crop, which is to be used for reeling and not for further reproduction is called “industrial” seed.

In a country where sericulture is a great and growing industry, it is not possible for Government grainages to meet any large part of the demand, and it is absolutely necessary to get the co-operation of intelligent rearers, who appreciate the issues involved, and can be persuaded, by concessions if necessary, to produce “industrial” seed with “cellular” seed issued from Government grainages, conformably to instructions issued by the Department of Sericulture, and under strict control and supervision. Such a system exists in Japan, and a beginning which promises well

has been made in Mysore. But as it will probably be some time before the Government or the aided grain-ages can meet the whole of the demand, it is necessary that the rearer should know how to select good seed for himself, and the most important points to be kept in view for this object will be given below for his guidance.

SELECTION OF COCOONS FOR SEED.

It is an outstanding fact that in a well established race, off-spring on the whole resemble parents, and in spite of individual differences, the race remains the same from generation to generation. The Mysore silk-worm is a light-green polivoltine, and was probably imported from South China, where a similar race is reared to this day; but the Mysore race has been searched and sifted and selected for Mysore by over a century of existence under all conditions prevalent here. It is certainly the best polivoltine race in India, and probably one of the best polivoltine races existing anywhere in the world. Attempts—of which some have been remarkably successful—have been made to improve the silk yielding quality by introducing strains of univoltine and bivoltine blood, but it has been always considered essential not to sacrifice or even jeopardise the characteristic Mysore excellences of robustness, resistance to disease, and uniformity.

The Mysore raiyat who does not get his seed from a Government or aided grainage, should aim at getting the best seed cocoon available of the *pure* Mysore race. The points to which he should devote attention are these:—

Cocoons which are normal and appropriate to the race in shape, size, colour, and weight should be selected; and in these, preference should be given to cocoons which are firm to the feel, and possess a thick layer of silk. Too small or too large cocoons should

be rejected, as also irregular-shaped cocoons and cocoons with uneven thickness of shell, whatever the cause of these abnormalities. Too small and too light cocoons mean feeble pupæ and a poor rearing. Stained cocoons should be rejected, for the stain is practically a disease culture.

The seed cocoon purchaser should select a rearer in a good locality who has a spacious rearing room and commands abundant supplies of mulberry. By good locality we mean a tract which has long maintained a reputation for good seed cocoons in virtue of its soil, climate, and the skill of its rearers. In a locality like that, the worms are likely to have benefited by a steady course of selection and good rearing, and popular reputation is generally based on earnest and careful, if unmethodical, observation of results. "Cellular" seed is best; "industrial" seed from recognised or aided grainages comes next; seed cocoons purchased from seed rearers of repute in localities famed for good seed comes last. The principal seed areas of the Mysore State are Bidadi, Kunigal, Magadi, Hebbur, and parts of Nagamangala. Rearers of particular areas have a rooted belief that seed from a certain place gives them better results than seed from anywhere else, and this preference based on long experience has probably some reason behind it. But whatever the area seed is got from, the purchaser must watch the crop from which he gets his seed cocoons, note the behaviour of the worms in going into and coming out of moults, and gather as much information as he can about the rearing.* Any indication of unequal worms, irregular moults, or dead worms in beds, etc., should decide him against buying cocoons of that crop for seed.

Supposing that the rearer has succeeded in get-

* Pasteur thought this first-hand observation so important that he said: "If I was a rearer, I would never rear eggs born of silk-worms which I had not observed repeatedly in the last days of their lives."—(Quoted by DR. PRINGLE JAMESON.)

ting good seed cocoons, he has next to keep them properly while waiting for the emergence of moths. Though the pupa is to all appearance in a dormant state, great and important changes are occurring in its internal economy. Various organ tissues are being dissolved and absorbed, and various other organs—the reproductive organs principally—are being built up, and this two-fold activity leaves the pupa but little vital energy for resisting disease. Hence the necessity for special protection.

The cocoons should be kept as far as possible in a uniform temperature of about 75° F, and the humidity should be between 65 and 75 per cent. They should not be exposed to draughts of air, or strong sunlight. A cool, darkened room is best. They should not be heaped on one another, but kept in a single layer in a tray.

The next point to know is how to select moths; for, however carefully seed cocoons might have been selected, it is not to be expected that all moths which come from them are perfect, or even uniformly good. A certain proportion will have to be rejected for congenital defects or for subsequent injury.

In moths the differences of shape and size due to sex are easily distinguished with a little practice. The *male* has a thinner abdomen than the female, and the hind portion looks more pointed and is usually a little raised. Its wings and antennæ are well developed; the marks on the body are dark and it is usually more active. The *female* has a comparatively large abdomen, which is blunt at the end. Its wings are not so strong as those of the male, and the antennæ are not so well developed. The markings on the body are fainter and thinner and the movements less active.

In selection, regard should be had to colour, shape, markings, and nature, which should all be well defined. The *male* should be selected for cleanness of build, activity, vigour, and well-defined sexual

characters such as well-developed antennæ, and wings. *Males* with heavy abdomen, or trailing hind part, or languid movement should be rejected. The *female* should have a capacious abdomen, thick in the middle, well rounded, and tapering uniformly towards both extremities.

Generally, moths which have not well-defined and normal sex characters, or which appear to present any abnormality at all, should not be selected. Among the abnormalities usually met with may be mentioned wrinkled, or shrunken, or deformed wings; humped or crooked bodies; trailing hind parts; stained abdomen; loss of scales.

Emergence of moths is never simultaneous even in the most uniform lot of seed cocoons, and other things being equal, male moths emerge earlier than females. But too great lateness in emergence is a sign of feebleness, and should be a ground of rejection. While keeping seed cocoons awaiting emergence of moths, it is a good plan to cover them with slashed or perforated paper, so that the moths on coming out might get on to the paper. This would prevent them from getting their feet caught in the floss, or from soiling the pierced cocoons with their excreta.

The number of males and females emerging in the same day is seldom equal. If the males are in excess, the surplus moths should be picked up before they manifest sexual activity and either preserved in a cool place for use next day, or else thrown away, so that they might not disturb the coupling moths with their fluttering. If there is a large preponderance of females, it would be better to use the more vigorous males for serving more than one female. In this case the male should be separated from the first coupling early to prevent its exhausting itself. The time generally allowed for coupling is 3 to 4 hours; in case the male is wanted again, 2 hours would do. The best temperature for pairing is from 75° to 80° F. The duration of coupling should be

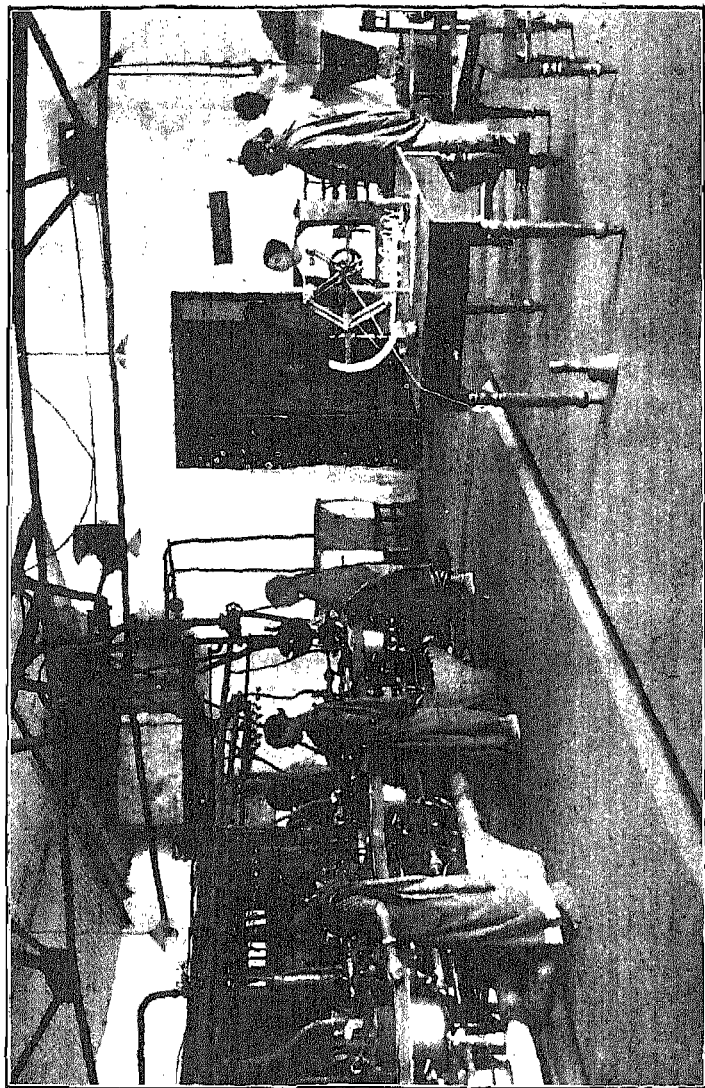
suited to the temperature, long for low temperatures and short for high ones. While pairing is in progress, the room should be kept free from draughts and other disturbing influences, and only subdued light should be allowed. After the coupling has continued sufficiently long, the pair should be separated gently, and the female transferred to the receptacle in which she lays eggs. In a grainage, this is a cellule or tin ring for each moth; in the raiyat's house it is a tray in which all the moths are placed in one fluttering mass, and all the eggs are collected in a mingled heap. The confinement of mother-moths in cellules and their subsequent treatment are appropriately portion of grainage technique, and a detailed exposition of these processes would be out of place in a book on rearing proper, and so we shall leave the subject at this point. After the raiyat has collected the silk-worm eggs, he has to attend to their hatching—a subject dealt with in Chapter III of this book.

It is obvious that the purchase of seed cocoons, and the subsequent operations down to the rearing of worms till they reach the 3rd stage can with advantage be done by all the rearers of a village on a co-operative basis. It generally happens that one or more of the rearers of a village possess exceptional skill in the selection of seed cocoons and in the care of young worms, and this rearer or rearers might be commissioned to buy the whole of the seed required for the village and to rear the young worms, which may afterwards be distributed among the several rearers. This would be nothing new in Mysore, as over large parts of the Kolar District *chawki* rearing, as the rearing of young worms is termed, is a recognised special branch of sericulture, and affords a livelihood to persons possessed of exceptional skill in seed selection. A more general adoption of this practice would save the waste of effort which occurs at present when each rearer undertakes

a long journey for purchasing a few hundred cocoons, and each one does for himself what one or two of the best could do much better for all. The village as a large and steady purchaser of seed cocoons could make better bargains than its rearers singly.

The result of a rearing depends largely on the care bestowed in the earlier stages ; and it is obvious that any arrangement which secures to all the worms of a village the maximum of care by the best rearers in these stages must necessarily be beneficial to the industry as a whole.

Sericulture is an industry which offers more scope for beneficial co-operation than almost any other, and the prosperity of Japanese sericulture is largely due to the excellence of its co-operative organisation,



INTERIOR OF MYSORE FILATURE : APPARATUS FOR TESTING THE SIZE OF SILK

APPENDIX I

Instructions and Rules for Government Grainages.

I. SELECTION OF COCOONS FOR SEED.

1. The worms whose cocoons are intended for seed should be observed carefully during their development. The number of diseased and weak worms and late moulting worms in each age should be carefully noted. If many of the worms are affected with *flache-rie* or any of them with *pebrine*, the cocoons should not be kept for seed. The worms should be uniform in development and individually strong and active. Cocoons from such worms only should be kept for seed.

2. The quantity of cocoons harvested from a lot of worms should also be carefully noted. If the cocoons harvested are less than 60 per cent of the worms brushed, or say roughly about 40 lbs. for 100 layings, such cocoons should not be used for seed.

3. Only fully ripe worms should be mounted on *chandrikes* if the cocoons are for seed.

4. The cocoons should not be removed from *chandrikes* earlier than 72 hours after mounting.

5. As far as possible, only cocoons from worms mounted on the second day after the worms of that rearing have commenced to ripen should be taken for seed.

6. As soon as a lot of cocoons are received in the grainage, a careful selection should be made. All inferior cocoons, cocoons with dead pupæ, disfigured cocoons and flabby cocoons should be discarded. Only superior and well-shaped cocoons having the characteristic colour, shape, size and lustre of the particular race should be kept for seed.

7. The selected cocoons should be spread in trays one layer deep.

8. A few inferior cocoons and a few cocoons with dead pupæ should be cut open, and the pupæ crushed and examined under the microscope. If the rejections for pebrine in these cases are less than 10 to 12 per cent then only the rest of the cocoons selected for seed should be kept. If the rejections are more than this limit, then it is better to stifle all the cocoons before the moths emerge.

9. The cocoons should be kept on stands in a well-ventilated room. It is best that the temperature in the room is below 85° F.

II. EMERGENCE OF MOTHS.

1. The moths generally emerge between 6 A.M. and 9 A.M. in warm months and between 7 A.M. and 10 A.M. in cold months.

2. Male moths generally emerge earlier than female moths on the same day. If the female moths are required for cross breeding, it is easier to start picking the male moths as they emerge and separate them from the female moths which emerge later, than to pick out female moths only.

3. The moths should be allowed to couple a few minutes after emergence, *i.e.*, when the wings have been fully spread out and dry.

4. Male moths which are active, strong, and well developed should be used for coupling. Weak, lazy, male moths with ill-developed wings should not be used.

5. Female moths which are ill-developed, or which have an abnormally large abdomen, or whose wings are not fully developed should not be kept for laying eggs.

6. At the time of copulation, the pairs should be kept in a quiet dark place. If there is a draught, the pairing moths may get separated and the female

may begin to lay eggs which eggs may get lost unless the couples have been kept on egg sheets in tin rings.

7. It is enough if the coupling is allowed to go on for 5 hours. If the male moths have to be used for recoupling, 4 hours for the first coupling and 6 to 7 hours for the second coupling will be satisfactory.

8. Superfluous male moths should not be allowed to flutter about the room as they disturb the pairing moths. They should be thrown into a vessel containing water.

9. After separating the male moths, the female moths should be kept on a piece of paper which should be gently shaken. This shaking will make the moths pass urine. Then the female moths should be left in the rings to lay eggs.

III. ARRANGEMENT OF TIN RINGS.

1. The rings should be arranged in rows, each row containing 5 rings, there being 4 such rows on each sheet of paper. Thus each sheet contains 20 rings only and is called an "egg sheet." Thus there will be 20 layings on each egg sheet. This number has been prescribed as most convenient for all practical purposes.

2. Each laying should be given a number commencing from the top left-hand corner of the sheet and ending in the bottom right-hand corner. Thus each laying will bear a number commencing at No. 1 and ending at No. 20.

3. The egg cards or sheets should be given serial numbers, each serial running current for one calendar month. For the sake of uniformity it is convenient to take the layings as having been prepared in the month in which the early moths, from a particular lot of cocoons emerge though the actual examination of moths is wholly or partly carried on during the subsequent month.

4. The following particulars should be entered on the bottom side of each egg sheet:—

(i) Race. (ii) Date of laying. (iii) Serial No.

5. The particulars for which headings are provided on the examination card should be fully entered before examination is commenced. Each examination card has 20 squares marked on it numbered from 1 to 20. This number is most convenient; for, it corresponds to the number of mortars in a crate and the number of preparations on the microscopic slide and is also a convenient fraction of 100 which is the unit for sale of eggs. Each number on the examination card denotes the number of the layings on the egg sheet. Opposite each number are two columns—one for noting the rejection for pebrine and the other that for flacherie. When more than one moth is examined at a time, the fact is indicated on the top of the examination card by noting the serial numbers of the egg sheets to which the examination card relates under the heading provided for the purpose.

6. At the time of examination, the preparer should enter the number or numbers of the egg sheet or sheets on the examination card. He should also remove the dead moths which have given only a small number of eggs or those whose eggs have turned brown or slaty, and make an entry against the corresponding number on the examination card. Then the preparer should take the moths in the order of the serial number on the egg sheet, put the moth into the mortar of the same number, crush the moth, prepare a slide and put it on the examination tray so that the numbers in all cases coincide. There should be five preparations on each slide corresponding to one line of mortars in the crate and one line of space on the examination tray. Then he should hand over the examination tray with the corresponding examination card to the examiner.

7. After handing over the preparation to the examiner, the preparer should go on with his work of

preparing slides from the moths of the next egg sheet. His entire attention should be devoted solely to the preparation of the slides and their transmission to the examiner.

8. The examiner should sit with his face to the north. He should keep the examination card on his right side where also the examination tray with the slides will be kept. He should go on with the examination of the preparations in the order shown on the examination card and if he finds pebrine spores or bacteria in any of the preparations, he should make a cross mark in red in the particular column on the examination card against the number on the preparation.

9. He should have a small tray with water (preferably a 2 per cent solution of formaline) kept on his left side. As soon as he finishes the examination of the preparations on one slide, he should put the slide into the water contained in the tray on his left side.

10. Soon after finishing all the preparations of one examination card, he should initial the card and keep it turned over.

11. The slides and cover glasses will be taken by one of the attendants who will put them in a sieve, wash them in running water, wipe and clean them and give them to the preparer for further use.

12. As soon as the preparations of a particular egg sheet have been handed over for examination, the mortars and pestles should be handed over to the attendant who will wash them in running water and keep them ready near the preparer for further work.

13. At the time of cleaning the mortars and pestles, the attendant should put all the refuse matter into a vessel in which a 2 per cent solution of formaline has been kept.

14. At the time of crushing the moths for preparing slides, instead of plain water a 2 per cent solution of caustic soda or caustic potash in a 2 per cent

solution of formaline should be used. The alkali dissolves the large quantity of fat contained in the moth and makes the pebrine spores readily visible. If the alkali is stronger than 5 per cent, then the pebrine spores are apt to lose the characteristic brilliancy by which they are easily detected.

15. The slides and cover glasses should be perfectly clean. The preparer should see that only a small quantity of the moth substance, just enough to cover the cover glass in a thin film is put on the slide. No substance should remain on the top of the cover glass as the alkali, if it comes in contact with the lens of the objective, may loosen its setting.

16. After each day's examination work is over, or as the examination progresses, if there is a separate cutter, each rejected laying should be marked on the egg sheet after comparing with the corresponding examination card; then it should be cut out and kept separate. The cutter should initial on the examination card. The correctness of the rejections should be checked later by some responsible grainage official, who should initial each examination card so scrutinised.

17. All the rejected layings should be burnt before the selected layings are sent out for distribution.

18. A register in the form prescribed should be opened in which should be entered all the details found on the egg card. Whenever layings are issued to a party, the number of the egg sheets containing these layings should be noted. An abstract of distribution should be given at the end of each lot.

19. It is best to examine one moth at a time. But as the interval between emergence of moths and hatching of eggs is short, two moths at a time may be examined. It is not safe to examine more than two moths at a time.

REGISTER TO BE MAINTAINED IN THE GRAINAGE

Date of laying	No. of egg sheet and examination card	No. of moths put on the sheet	Pebrine	Flacherie	Dead	Poor	Brown	Good	Date of examination	Name of examiner	Disposal of layings. To whom? how many? and of what egg cards?

N.B.—As soon as a lot of cocoons are received for seed in the grainage, the following points should be noted in the register:—

Locality from which the cocoons were received.

No. of cocoons received.

No. of cocoons selected and kept for seed.

As soon as the female moths are left in the rings to lay eggs, the date of emergence, the number of the egg sheet and the number of moths left on the sheet should be entered in the register.

As soon as the day's examination is over, the rejected layings cut and removed, the particulars should be entered in the register.

At the conclusion of the examination of moths of each lot of cocoons, the percentage of rejections, etc., should be worked out and noted. An abstract of the distribution of the layings of the particular batch also should be noted.

FORM OF EXAMINATION CARD.

..... GRAINAGE.

Egg Sheet No. { Date of Laying.....
 { Date of Examination.....

Locality of Seed Cocoons.....

Race.....

No.	Peb.	Fla.	No.	Peb.	Fla.
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

Initials of Examiner

Initials of Cutter

Initials of Checker

Abstract of Rejections.

Pebrine....., Flacherie....., Dead.....,

Brown....., Small.....

APPENDIX II.

Instructions for the Disinfection of Rearing Houses and Appliances.

1. The walls and floor of the rearing house and all appliances should be thoroughly washed with clean water before disinfection. The stand should be wiped with a wet cloth. The trays should be smeared with cow-dung, and dried; the hand trays and *chandrikes* and big *chandrikes* should be cleaned with water. All these should be thoroughly dried in the sun before being put back into the rearing house. Mere disinfection without thorough cleaning is not enough.

2. Before starting disinfection, all the holes, cracks, and crevices in the windows, etc., of the rearing house should be closed up so that no gas can escape.

3. The temperature of the rearing house should be not less than 75° F at the time of disinfection and for at least 6 hours afterwards. This can be obtained by finishing the disinfection before 12 noon. If the temperature is below 75° F at the time of starting the disinfection, it should be raised by keeping a fire in the rearing house.

4. The disinfectant should be applied in a thin spray, which should come in direct contact with all the surfaces, corners, walls and floor of the rearing house and also all parts of the stands, trays, *chandrikes* and other appliances. Formaline kills the pebrine spores when it directly comes in contact with them.

5. Formaline, corrosive sublimate and sulphur fumes are all used as disinfectants. But sulphur fumes have not much action on pebrine and corrosive sublimate is so highly poisonous as to require

extreme care in handling. The best disinfectant for practical use is formaline.

6. Formaline is the name given to a solution of formaldehyde gas. This is sold in commerce as a clear watery liquid and contains about 35 to 40 per cent of the gas. When preparing a solution of formaline for disinfecting the rearing houses, we must take into consideration only the quantity of gas contained in the solution.

7. As the vapours of formaldehyde are extremely irritating to the mucus membrane of the eyes, nose and mouth at the time of disinfection, these organs should be well protected.

8. The percentage of the gas is generally indicated on the bottles containing formaline. Those supplied by Merck, Germany, are generally 40 per cent solutions

9. Formaline should be used as a 2 per cent solution to destroy pebrine. In this strength almost all the spores are destroyed. To prepare a 2 per cent solution for disinfection from a solution of given percentage, the following formula should be adopted :—

$$\frac{(\text{Strength of original solution} - \text{Strength required})}{\text{Strength required}} = \frac{\text{The quantity of water to be added,}}{1}$$

For example, to find out how much water should be added to obtain a 2 per cent solution of formaline from a 40 per cent solution :—

$$\frac{(40-2)}{2} = \frac{38}{2} = 19 \text{ times.}$$

If we take 100 c.c. of 40 per cent formaline and add 1,900 c.c. of water, then we get a 2 per cent solution.

10. At the time of preparing the solution for disinfection, it is better to use warm water. From one bottle of formaline which generally contains about 450 c.c. of the solution, by adding $(450 \times 19) = 8,550$ c.c. of water we can get 9,000 c.c. of 2 per cent solution.

11. The surface area of the rearing room should be found out. The length and breadth of the floor, the length and height of the walls should be carefully measured.

The total area of a rectangular room = $\text{Length} \times \text{Breadth}$.
Floor area.

$\text{Length} \times \text{Height of each wall} \times 2 = \text{area of two walls}$.

$\text{Breadth} \times \text{Height of each wall} \times 2 = \text{area of two other walls}$.

Add up and we get the area to be disinfected. To this in the case of a terraced room, add surface of ceiling and in that of a tile roof, the surface of the two slopes.

To disinfect 100 sq. feet of a space, 800 c.c. of a 2 per cent solution of formaline should be used.

Adopting these figures, we should find out the total quantity of 2 per cent formaline required and then prepare the disinfectant.

12. *For disinfecting the appliances.*—For every 200 sq. feet of the appliances, if they are to be disinfected in the same room which will be disinfected, it is enough if we use 250 c.c. of a 2 per cent solution of formaline.

13. The rearing house should be completely closed up for at least 15 hours after disinfection.

14. The rearing house should be completely opened (windows, etc.) for at least 24 hours and the smell of formaline should be removed with water to which a little ammonia has been added before worms are taken into the rearing house.

15. At the time of rearing, steps should be taken to prevent contagion from outside. Diseased worms, etc., found at the time of rearing should be put into a vessel which contains formaline solution.